CORRECTED VERSION*

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
C07K 1/00, 14/00, 17/00, C07H 19/00, 21/00, 21/02, 21/04, A01N 43/04, A61K 31/70, G01N 33/53

A1

(11) International Publication Number: WO 96/35708

(43) International Publication Date: 14 November 1996 (14.11.96)

(21) International Application Number: PCT/US96/06664

(22) International Filing Date: 10 May 1996 (10.05.96)

(30) Priority Data:
08/439,725 12 May 1995 (12.05.95) US

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(81) Designated States: AU, CA, JP, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: FIBROBLAST GROWTH FACTOR HOMOLOGOUS FACTOR-1 (FHF-1) AND METHODS OF USE

(57) Abstract

A novel protein, fibroblast growth factor homologous factor-1 (FHF-1), the polynucleotide sequence encoding FHF-1, and the deduced amino acid sequence are disclosed. Also disclosed are diagnostic and therapeutic methods of using the FHF-1 polypeptide and polynucleotide sequences and antibodies which specifically bind to FHF-1.

* (Referred to in PCT Gazette No. 05/1997, Section II)

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BNSDOCID: <WO___9635708A1_IA>

FIBROBLAST GROWTH FACTOR HOMOLOGOUS FACTOR-1 (FHF-1) AND METHODS OF USE

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The invention relates generally to growth factors and specifically to a novel member of the fibroblast growth factor family, denoted fibroblast growth factor homologous factor-1 (FHF-1) and the polynucleotide encoding FHF-1.

2. DESCRIPTION OF RELATED ART

The fibroblast growth factor family encompasses a group of structurally related proteins with a wide range of growth promoting, survival, and/or differentiation activities in vivo and in vitro (reviewed in Baird, A., and Gospodarowicz, D. *Ann N.Y. Acad. Sci.* 638: 1, 1991; Eckenstein, F.P., *J. Neurobiology* 25: 1467, 1994; Mason, I.J. *Cell* 78: 547, 1994). As of December 1994, nine members of this family had been characterized by molecular cloning. The first two members of the family to be characterized, acidic fibroblast growth factor (aFGF/FGF-1) and basic fibroblast growth factor (bFGF/FGF-2), have been found in numerous tissues, including for example brain, eye, kidney, placenta, and adrenal (Jaye *et al., Science* 233: 541, 1986; Abraham *et al., Science* 233: 545, 1986). These factors have been shown to be potent mitogens and survival factors for a variety of mesoderm and neurectoderm-derived tissues, including fibroblasts, endothelial cells, hippocampal and cerebral cortical neurons, and astroglia (Burgess, W. H. and Maciag, T., *Ann. Rev. Biochemistry* 58: 575, 1989). Additional members of the FGF family include: int-2/FGF-3, identified as one of the frequent sites of integration of the mouse mammary tumor virus, and therefore a presumptive oncogenic factor (Smith *et al., EMBO J.* 7: 1013, 1988); FGF-4 (Delli-Bovi *et al., Cell* 50: 729, 1987) and FGF-5 (Zhan *et al., Mol. Cell Biol.*8: 3487, 1988) as transforming genes in the NIH 3T3 transfection assay; FGF-6, isolated by molecular cloning based on its homology to FGF-4 (Marics *et al., Oncogene* 4: 335 (1989); keratinocyte growth factor/ FGF-7, identified as a mitogen for keratinocytes (Finch *et al., Science* 245: 752, 1989); FGF-8 as an androgen-induced mitogen for mammary carcinoma cells (Tanaka *et*

al., Proc. Natl. Acad. Sci. USA 89: 8928, 1992); and FGF-9 as a mitogen for primary astrocytes (Miyamoto *et al., Mol. Cell Biol.* 13: 4251, 1993). Several of the FGFs, including aFGF and bFGF, lack a classical signal sequence; the mechanism by which they are secreted is not known.

All members of the FGF family share approximately 25% or more amino acid sequence identity, a degree of homology indicating that they are likely to share nearly identical three-dimensional structures. Support for this inference comes from a comparison of the three-dimensional structures of bFGF and interleukin 1-beta determined by x-ray diffraction (Eriksson *et al., Proc. Natl. Acad. Sci USA* 88: 3441, 1991; Zhang *et al., Proc. Natl. Acad. Sci USA* 88: 3446, 1991; Ago *et al., J. Biochem.* 110: 360, 1991). Although these proteins share only 10% amino acid identity, the alpha carbon backbones of the two crystal structures can be superimposed with a root-mean square deviation of less than 2 angstroms (Zhang *et al., Proc. Natl. Acad. Sci USA* 88: 3446, 1991). Both proteins consist almost entirely of beta-sheets, which form a barrel composed of three copies of a four-stranded beta-meander motif. The likely heparin- and receptor-binding regions are located on nearby regions on one face of the protein.

aFGF, bFGF, and FGF-7/KGF have been shown to exert some or all of their biological activity through high affinity binding to cell surface tyrosine kinase receptors (*e.g.*, Lee, P. L., *et al., Science* 245: 57, 1989; reviewed in Johnson, D.E. and Williams, L.T., *Adv. Cancer Res.* 60: 1, 1993). Many members of the FGF family also bind tightly to heparin, and a terniary complex of heparin, FGF, and transmembrane receptor may be the biologically relevant signalling species. Thus far four different genes have been identified that encode receptors for FGF family members. Recent work has shown that receptor diversity is increased by differential mRNA splicing within the extracellular ligand binding domain, with the result that multiple receptor isoforms with different ligand binding properties can be encoded by the same gene (Johnson, D.E. and Williams, L.T., *Adv. Cancer Res.* 60: 1, 1993). In tissue culture systems, the binding of aFGF or bFGF to its cell surface receptor activates phospholipase C-gamma (Burgess, W. H. *et al., Mol. Cell Biol.* 10: 4770, 1990), a pathway known to integrate a variety of mitogenic signals.

Identification and characterization of new members of the FGF family will provide insights into the mechanisms by which cells and organs control their growth, survival, senescence, differentiation, and recovery from injury.

SUMMARY OF THE INVENTION

The present invention provides a cell growth, survival or differentiation factor, FHF-1 and a polynucleotide sequence which encodes the factor. This factor is involved in the growth, survival, and or differentiation of cells within the central nervous system (CNS) as well as in peripheral tissues.

The invention provides a method for detecting alterations in FHF-1 gene expression which are diagnostic of neurodegenerative or neoplastic disorders. In another embodiment, the invention provides a method for treating a neurodegenerative or neoplastic disorder by modulating the expression or activity of FHF-1.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows the nucleotide and predicted amino acid sequence of human FHF-1.

Figure 2 shows the alignment of the amino acid sequence of human FHF-1 and each of the other nine members of the FGF family. Conserved residues are highlighted. The FGF family members are: aFGF/FGF-1 (Jaye *et al., Science* 233: 541, 1986), bFGF/FGF-2 (Abraham *et al., Science* 233: 545, 1986), int-2/FGF-3 (Smith *et al., EMBO J.* 7: 1013, 1988), FGF-4 (Delli-Bovi *et al., Cell* 50: 729, 1987), FGF-5 (Zhan *et al., Mol. Cell Biol.* 8: 3487, 1988), FGF-6 (Marics *et al., Oncogene* 4: 335, 1989); keratinocyte growth factor/ FGF-7 (Finch *et al., Science* 245: 752, 1989), FGF-8 (Tanaka *et al., Proc. Natl. Acad. Sci. USA* 89: 8928, 1992), and FGF-9 (Miyamoto *et al., Mol. Cell Biol.* 13: 4251, 1993).

Figure 3 shows a dendrogram in which the length of each path connecting any pair of FGF family members is proportional to the degree of amino acid sequence divergence of that pair.

Figure 4 shows that the gene encoding FHF-1 is located on human chromosome 3. The human specific hybridization is found on chromosome 3.

Figure 5 shows the production of FHF-1 in transfected human embryonic kidney cells. Lanes 1, 3, and 5, total cell protein; lanes 2, 4, and 6 protein present in the medium (secreted protein). Lanes 1 and 2, transfection with cDNA encoding human growth hormone; lanes 3 and 4, transfection with cDNA encoding FHF-1; lanes 5 and 6, transfection with cDNA encoding a novel surface receptor fused to an immunoglobulin constant region. Protein standards are shown to the left; from top to bottom their molecular masses are 220, 97, 66, 46, 30, 21.5, and 14.3 kD.

Figure 6 shows the tissue specificity of FHF-1 expression. Ten micrograms of total RNA from the indicated mouse tissues was prepared (Chomczinski & Sacchi. Anal. Biochem. 162: 156, 1987) and used for RNAse protection (Ausabel et al., Current Protocols in Molecular Biology; New York: Wiley Interscience, 1987) with a mouse FHF-1 antisense probe that spanned 212 bases of exon 1 and the adjacent 100 bases of intron 1. RNAse protection at the size expected for the 212 base exon 1 region of the probe (arrowhead) was observed with RNA from brain, eye, and testis.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a growth factor, FHF-1, and a polynucleotide sequence encoding FHF-1. FHF-1 is expressed at high levels in brain, eye and testes tissues. In one embodiment, the invention provides a method for detection of a cell proliferative disorder of central nervous system or testes origin which is associated with FHF-1 expression or function. In another embodiment, the invention provides a method for treating a cell proliferative or immunologic disorder by using an agent which suppresses or enhances FHF-1 expression or activity.

The structural homology between the FHF-1 protein of this invention and the members of the FGF family, indicates that FHF-1 is a new member of the family of growth factors. Based on the known activities of many of the other members, it can be expected that FHF-1 will also possess biological activities that will make it useful as a diagnostic and therapeutic reagent.

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Many growth factors have expression patterns or possess activities that relate to the function of the nervous system. For example, one growth factor in the TGF family, namely GDNF, has been shown to be a potent neurotrophic factor that can promote the survival of dopaminergic neurons (Lin, *et al., Science*, 260:1130). Another family member, namely dorsalin-1, is capable of promoting the differentiation of neural crest cells (Basler, *et al., Cell*, 73:687, 1993). The inhibins and activins have been shown to be expressed in the brain (Meunier, *et al., Proc. Nat'l. Acad. Sci.*, USA, 85:247, 1988; Sawchenko, *et al., Nature*, 334:615, 1988), and activin has been shown to be capable of functioning as a nerve cell survival molecule (Schubert, *et al., Nature*, 344:868, 1990). Another TGF family member, namely GDF-1, is nervous system-specific in its expression pattern (Lee, *Proc. Nat'l. Acad. Sci., USA*, 88:4250, 1991), and certain other family members, such as Vgr-1 (Lyons, *et al., Proc. Nat'l. Acad. Sci., USA*, 86:4554, 1989; Jones, *et al., Development*, 111:581, 1991), OP-1 (Ozkaynak, *et al., J. Biol. Chem.*, 267:25220, 1992), and BMP-4 (Jones, *et al., Development*, 111:531, 1991), are also known to be expressed in the nervous system.

The expression of FHF-1 in brain and eye suggests that FHF-1 may also possess activities that relate to the function of the nervous system. FHF-1 may have neurotrophic activities for various neuronal populations. Hence, FHF-1 may have *in vitro* and *in vivo* applications in the treatment of neurodegenerative diseases, such as amyotrophic lateral sclerosis, or in maintaining cells or tissues in culture prior to transplantation.

In a first embodiment, the present invention provides a sbstantially pure fibroblast growth factor homologous factor-1 (FHF-1) characterized by aving a molecular weight of about 30kD as determined by reducing SDS-PAGE and having essentially the amino acid sequence of SEQ ID NO:2. The term "substantially pure" as used herein refers to FHF-1 which is substantially free of other proteins, lipids, carbohydrates or other materials with which it is naturally associated. One skilled in the art can purify FHF-1 using standard techniques for protein purification. The substantially pure polypeptide will yield a single major band on a non-reducing polyacrylamide gel. The purity of the FHF-1 polypeptide can also be determined by amino-terminal amino acid sequence analysis. FHF-1 polypeptide includes functional fragments of the polypeptide, as long as the activity of FHF-1 remains.

Smaller peptides containing the biological activity of FHF-1 are included in the invention.

The invention provides polynucleotides encoding the FHF-1 polypeptide. These polynucleotides include DNA, cDNA and RNA sequences which encode FHF-1. It is understood that all polynucleotides encoding all or a portion of FHF-1 are also included herein, as long as they encode a polypeptide with FHF-1 activity. Such polynucleotides include naturally occurring, synthetic, and intentionally manipulated polynucleotides. For example, FHF-1 polynucleotide may be subjected to site-directed mutagenesis. The polynucleotide sequence for FHF-1 also includes antisense sequences. The polynucleotides of the invention include sequences that are degenerate as a result of the genetic code. There are 20 natural amino acids, most of which are specified by more than one codon. Therefore, all degenerate nucleotide sequences are included in the invention as long as the amino acid sequence of FHF-1 polypeptide encoded by the nucleotide sequence is functionally unchanged.

Specifically disclosed herein is a DNA sequence encoding the human FHF-1 gene. The sequence contains an open reading frame encoding a polypeptide 244 amino acids in length. The human FHF-1 inititiator methionine codon shown in FIGURE 1 at position 332-334 is the first ATG codon following the in-frame stop codon at nucleotides 323-325; a good consensus ribosome binding site (TGGCC**ATG**G; Kozak, *Nucleic Acids Res.*, 15: 8125, 1987) is found at this position. The next methionine codon within the open reading frame is encountered 86 codons 3' of the putative initiator methionine codon. As observed for aFGF and bFGF, the amino-terminus of the primary translation product of FHF-1 does not conform to the consensus sequence for a signal peptide to direct cotranslational insertion across the endoplasmic reticulum membrane. The FHF-1 sequence lacks potential asn-X-ser/thr site for asparagine-linked glycosylation. Preferably, the human FHF-1 nucleotide sequence is SEQ ID NO:1 and the deduced amino acid sequence is preferably SEQ ID NO:2.

The polynucleotide encoding FHF-1 includes SEQ ID NO:1 as well as nucleic acid sequences complementary to SEQ ID NO:1. A complementary sequence may include an antisense nucleotide. When the sequence is RNA, the deoxynucleotides

A, G, C, and T of SEQ ID NO:1 is replaced by ribonucleotides A, G, C, and U, respectively. Also included in the invention are fragments of the above-described nucleic acid sequences that are at least 15 bases in length, which is sufficient to permit the fragment to selectively hybridize to DNA that encodes the protein of SEQ ID NO:2 under physiological conditions. Specifically, the fragments should hybridize to DNA encoding FHF-1 protein under stringent conditions.

The FGF family member most homologous to FHF-1 is FGF-9, which shares 27% amino acid identity when aligned with 10 gaps. Minor modifications of the FHF-1 primary amino acid sequence may result in proteins which have substantially equivalent activity as compared to the FHF-1 polypeptide described herein. Such proteins include those as defined by the term "having essentially the amino acid sequence of SEQ ID NO:2". Such modifications may be deliberate, as by site-directed mutagenesis, or may be spontaneous. All of the polypeptides produced by these modifications are included herein as long as the biological activity of FHF-1 still exists. Further, deletion of one or more amino acids can also result in a modification of the structure of the resultant molecule without significantly altering its biological activity. This can lead to the development of a smaller active molecule which would have broader utility. For example, one can remove amino or carboxy terminal amino acids which are not required for FHF-1 biological activity.

The FHF-1 polypeptide of the invention encoded by the polynucleotide of the invention includes the disclosed sequence (SEQ ID NO:2) and conservative variations thereof. The term "conservative variation" as used herein denotes the replacement of an amino acid residue by another, biologically similar residue. Examples of conservative variations include the substitution of one hydrophobic residue such as isoleucine, valine, leucine or methionine for another, or the substitution of one polar residue for another, such as the substitution of arginine for lysine, glutamic for aspartic acid, or glutamine for asparagine, and the like. The term "conservative variation" also includes the use of a substituted amino acid in place of an unsubstituted parent amino acid provided that antibodies raised to the substituted polypeptide also immunoreact with the unsubstituted polypeptide.

DNA sequences of the invention can be obtained by several methods. For example, the DNA can be isolated using hybridization techniques which are well known in the art. These include, but are not limited to: 1) hybridization of genomic or cDNA libraries with probes to detect homologous nucleotide sequences, 2) polymerase chain reaction (PCR) on genomic DNA or cDNA using primers capable of annealing to the DNA sequence of interest, and 3) antibody screening of expression libraries to detect cloned DNA fragments with shared structural features.

Preferably the FHF-1 polynucleotide of the invention is derived from a mammalian organism, and most preferably from human. Screening procedures which rely on nucleic acid hybridization make it possible to isolate any gene sequence from any organism, provided the appropriate probe is available. Oligonucleotide probes, which correspond to a part of the sequence encoding the protein in question, can be synthesized chemically. This requires that short, oligopeptide stretches of amino acid sequence must be known. The DNA sequence encoding the protein can be deduced from the genetic code, however, the degeneracy of the code must be taken into account. It is possible to perform a mixed addition reaction when the sequence is degenerate. This includes a heterogeneous mixture of denatured double-stranded DNA. For such screening, hybridization is preferably performed on either single-stranded DNA or denatured double-stranded DNA. Hybridization is particularly useful in the detection of cDNA clones derived from sources where an extremely low amount of mRNA sequences relating to the polypeptide of interest are present. In other words, by using stringent hybridization conditions directed to avoid non-specific binding, it is possible, for example, to allow the autoradiographic visualization of a specific cDNA clone by the hybridization of the target DNA to that single probe in the mixture which is its complete complement (Wallace, *et al., Nucl. Acid Res.*, 9:879, 1981; Maniatis, *et al., Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor, N.Y. 1989).

The development of specific DNA sequences encoding FHF-1 can also be obtained by: 1) isolation of double-stranded DNA sequences from the genomic DNA; 2) chemical manufacture of a DNA sequence to provide the necessary codons for the polypeptide of interest; and 3) *in vitro* synthesis of a double-stranded DNA sequence by reverse transcription of mRNA isolated from a eukaryotic donor cell. In the latter

case, a double-stranded DNA complement of mRNA is eventually formed which is generally referred to as cDNA.

Of the three above-noted methods for developing specific DNA sequences for use in recombinant procedures, the isolation of genomic DNA isolates is the least common. This is especially true when it is desirable to obtain the microbial expression of mammalian polypeptides due to the presence of introns.

The synthesis of DNA sequences is frequently the method of choice when the entire sequence of amino acid residues of the desired polypeptide product is known. When the entire sequence of amino acid residues of the desired polypeptide is not known, the direct synthesis of DNA sequences is not possible and the method of choice is the synthesis of cDNA sequences. Among the standard procedures for isolating cDNA sequences of interest is the formation of plasmid- or phage-carrying cDNA libraries which are derived from reverse transcription of mRNA which is abundant in donor cells that have a high level of genetic expression. When used in combination with polymerase chain reaction technology, even rare expression products can be cloned. In those cases where significant portions of the amino acid sequence of the polypeptide are known, the production of labeled single or double-stranded DNA or RNA probe sequences duplicating a sequence putatively present in the target cDNA may be employed in DNA/DNA hybridization procedures which are carried out on cloned copies of the cDNA which have been denatured into a single-stranded form (Jay, *et al., Nucl. Acid Res.*, 11:2325, 1983).

A cDNA expression library, such as lambda gt11, can be screened indirectly for FHF-1 peptides having at least one epitope, using antibodies specific for FHF-1. Such antibodies can be either polyclonally or monoclonally derived and used to detect expression product indicative of the presence of FHF-1 cDNA.

DNA sequences encoding FHF-1 can be expressed *in vitro* by DNA transfer into a suitable host cell. "Host cells" are cells in which a vector can be propagated and its DNA expressed. The term also includes any progeny of the subject host cell. It is understood that all progeny may not be identical to the parental cell since there may be mutations that occur during replication. However, such progeny are included

when the term "host cell" is used. Methods of stable transfer, meaning that the foreign DNA is continuously maintained in the host, are known in the art.

In the present invention, the FHF-1 polynucleotide sequences may be inserted into a recombinant expression vector. The term "recombinant expression vector" refers to a plasmid, virus or other vehicle known in the art that has been manipulated by insertion or incorporation of the FHF-1 genetic sequences. Such expression vectors contain a promoter sequence which facilitates the efficient transcription of the inserted genetic sequence of the host. The expression vector typically contains an origin of replication, a promoter, as well as specific genes which allow phenotypic selection of the transformed cells. Vectors suitable for use in the present invention include, but are not limited to the T7-based expression vector for expression in bacteria (Rosenberg, *et al.*, *Gene*, 56:125, 1987), the pMSXND expression vector for expression in mammalian cells (Lee and Nathans, *J. Biol. Chem.*, 263:3521, 1988) and baculovirus-derived vectors for expression in insect cells. The DNA segment can be present in the vector operably linked to regulatory elements, for example, a promoter (e.g., T7, metallothionein I, or polyhedrin promoters).

Polynucleotide sequences encoding FHF-1 can be expressed in either prokaryotes or eukaryotes. Hosts can include microbial, yeast, insect and mammalian organisms. Methods of expressing DNA sequences having eukaryotic or viral sequences in prokaryotes are well known in the art. Biologically functional viral and plasmid DNA vectors capable of expression and replication in a host are known in the art. Such vectors are used to incorporate DNA sequences of the invention.

Transformation of a host cell with recombinant DNA may be carried out by conventional techniques as are well known to those skilled in the art. Where the host is prokaryotic, such as *E. coli*, competent cells which are capable of DNA uptake can be prepared from cells harvested after exponential growth phase and subsequently treated by the $CaCl_2$ method using procedures well known in the art. Alternatively, $MgCl_2$ or RbCl can be used. Transformation can also be performed after forming a protoplast of the host cell if desired.

When the host is a eukaryote, such methods of transfection of DNA as calcium phosphate co-precipitates, conventional mechanical procedures such as micro-

injection, electroporation, insertion of a plasmid encased in liposomes, or virus vectors may be used. Eukaryotic cells can also be cotransformed with DNA sequences encoding the FHF-1 of the invention, and a second foreign DNA molecule encoding a selectable phenotype, such as the herpes simplex thymidine kinase gene. Another method is to use a eukaryotic viral vector, such as simian virus 40 (SV40) or bovine papilloma virus, to transiently infect or transform eukaryotic cells and express the protein. (see for example, *Eukaryotic Viral Vectors*, Cold Spring Harbor Laboratory, Gluzman ed., 1982).

Isolation and purification of microbial expressed polypeptide, or fragments thereof, provided by the invention, may be carried out by conventional means including preparative chromatography and immunological separations involving monoclonal or polyclonal antibodies.

The FHF-1 polypeptides of the invention can also be used to produce antibodies which are immunoreactive or bind to epitopes of the FHF-1 polypeptides. Antibody which consists essentially of pooled monoclonal antibodies with different epitopic specificities, as well as distinct monoclonal antibody preparations are provided. Monoclonal antibodies are made from antigen containing fragments of the protein by methods well known in the art (Kohler, *et al., Nature*, 256:495, 1975; *Current Protocols in Molecular Biology*, Ausubel, *et al.*, ed., 1989).

The term "antibody" as used in this invention includes intact molecules as well as fragments thereof, such as Fab, $F(ab')_2$, and Fv which are capable of binding the epitopic determinant. These antibody fragments retain some ability to selectively bind with its antigen or receptor and are defined as follows:

(1) Fab, the fragment which contains a monovalent antigen-binding fragment of an antibody molecule can be produced by digestion of whole antibody with the enzyme papain to yield an intact light chain and a portion of one heavy chain;

(2) Fab', the fragment of an antibody molecule can be obtained by treating whole antibody with pepsin, followed by reduction, to yield an intact light chain and a portion of the heavy chain; two Fab' fragments are obtained per antibody molecule;

(3) $(Fab')_2$, the fragment of the antibody that can be obtained by treating whole antibody with the enzyme pepsin without subsequent reduction; $F(ab')_2$ is a dimer of two Fab' fragments held together by two disulfide bonds;

(4) Fv, defined as a genetically engineered fragment containing the variable region of the light chain and the variable region of the heavy chain expressed as two chains; and

(5) Single chain antibody ("SCA"), defined as a genetically engineered molecule containing the variable region of the light chain, the variable region of the heavy chain, linked by a suitable polypeptide linker as a genetically fused single chain molecule.

Methods of making these fragments are known in the art. (See for example, Harlow and Lane, *Antibodies: A Laboratory Manual*, Cold Spring Harbor Laboratory, New York (1988), incorporated herein by reference).

As used in this invention, the term "epitope" means any antigenic determinant on an antigen to which the paratope of an antibody binds. Epitopic determinants usually consist of chemically active surface groupings of molecules such as amino acids or sugar side chains and usually have specific three dimensional structural characteristics, as well as specific charge characteristics.

Antibodies which bind to the FHF-1 polypeptide of the invention can be prepared using an intact polypeptide or fragments containing small peptides of interest as the immunizing antigen. The polypeptide or a peptide used to immunize an animal can be derived from translated cDNA (see for example, EXAMPLES 4 and 6) or chemical synthesis which can be conjugated to a carrier protein, if desired. Such commonly used carriers which are chemically coupled to the peptide include keyhole limpet hemocyanin (KLH), thyroglobulin, bovine serum albumin (BSA), and tetanus toxoid. The coupled peptide is then used to immunize the animal (*e.g.*, a mouse, a rat, or a rabbit).

If desired, polyclonal or monoclonal antibodies can be further purified, for example, by binding to and elution from a matrix to which the polypeptide or a peptide to which

the antibodies were raised is bound. Those of skill in the art will know of various techniques common in the immunology arts for purification and/or concentration of polyclonal antibodies, as well as monoclonal antibodies (See for example, Coligan, *et al.*, Unit 9, *Current Protocols in Immunology*, Wiley Interscience, 1994, incorporated by reference).

It is also possible to use the anti-idiotype technology to produce monoclonal antibodies which mimic an epitope. For example, an anti-idiotypic monoclonal antibody made to a first monoclonal antibody will have a binding domain in the hypervariable region which is the "image" of the epitope bound by the first monoclonal antibody.

The term "cell-proliferative disorder" denotes malignant as well as non-malignant cell populations which often appear to differ from the surrounding tissue both morphologically and genotypically. Malignant cells (*i.e.* cancer) develop as a result of a multistep process. The FHF-1 polynucleotide that is an antisense molecule is useful in treating malignancies of the various organ systems, particularly, for example, cells in the central nervous system, including neural tissue, testes, and cells of the eye. Essentially, any disorder which is etiologically linked to altered expression of FHF-1 could be considered susceptible to treatment with a FHF-1 suppressing reagent. One such disorder is a malignant cell proliferative disorder, for example.

For purposes of the invention, an antibody or nucleic acid probe specific for FHF-1 may be used to detect FHF-1 polypeptide (using antibody) or polynucleotide (using nucleic acid probe) in biological fluids or tissues. The invention provides a method for detecting a cell proliferative disorder of neural tissue or testes, for example, which comprises contacting an anti-FHF-1 antibody or nucleic acid probe with a cell suspected of having a FHF-1 associated disorder and detecting binding to the antibody or nucleic acid probe. The antibody reactive with FHF-1 or the nucleic acid probe is preferably labeled with a compound which allows detection of binding to FHF-1. Any specimen containing a detectable amount of antigen or polynucleotide can be used. A preferred sample of this invention is CNS, *e.g.*, neural tissue or cerebrospinal fluid, testes, or eye tissue. The level of FHF-1 in the suspect cell can

be compared with the level in a normal cell to determine whether the subject has a FHF-1-associated cell proliferative disorder. Preferably the subject is human.

When the cell component is nucleic acid, it may be necessary to amplify the nucleic acid prior to binding with an FHF-1 specific probe. Preferably, polymerase chain reaction (PCR) is used, however, other nucleic acid amplification procedures such as ligase chain reaction (LCR), ligated activated transcription (LAT) and nucleic acid sequence-based amplification (NASBA) may be used.

The antibodies of the invention can be used in any subject in which it is desirable to administer *in vitro* or *in vivo* immunodiagnosis or immunotherapy. The antibodies of the invention are suited for use, for example, in immunoassays in which they can be utilized in liquid phase or bound to a solid phase carrier. In addition, the antibodies in these immunoassays can be detectably labeled in various ways. Examples of types of immunoassays which can utilize antibodies of the invention are competitive and non-competitive immunoassays in either a direct or indirect format. Examples of such immunoassays are the radioimmunoassay (RIA) and the sandwich (immunometric) assay. Detection of the antigens using the antibodies of the invention can be done utilizing immunoassays which are run in either the forward, reverse, or simultaneous modes, including immunohistochemical assays on physiological samples. Those of skill in the art will know, or can readily discern, other immunoassay formats without undue experimentation.

The antibodies of the invention can be bound to many different carriers and used to detect the presence of an antigen comprising the polypeptide of the invention. Examples of well-known carriers include glass, polystyrene, polypropylene, polyethylene, dextran, nylon, amylases, natural and modified celluloses, polyacrylamides, agaroses and magnetite. The nature of the carrier can be either soluble or insoluble for purposes of the invention. Those skilled in the art will know of other suitable carriers for binding antibodies, or will be able to ascertain such, using routine experimentation.

There are many different labels and methods of labeling known to those of ordinary skill in the art. Examples of the types of labels which can be used in the present invention include enzymes, radioisotopes, fluorescent compounds, colloidal metals,

chemiluminescent compounds, phosphorescent compounds, and bioluminescent compounds. Those of ordinary skill in the art will know of other suitable labels for binding to the antibody, or will be able to ascertain such, using routine experimentation.

Another technique which may also result in greater sensitivity consists of coupling the antibodies to low molecular weight haptens. These haptens can then be specifically detected by means of a second reaction. For example, it is common to use such haptens as biotin, which reacts with avidin, or dinitrophenyl, puridoxal, and fluorescein, which can react with specific antihapten antibodies.

In using the monoclonal antibodies of the invention for the *in vivo* detection of antigen, the detectably labeled antibody is given a dose which is diagnostically effective. The term "diagnostically effective" means that the amount of detectably labeled monoclonal antibody is administered in sufficient quantity to enable detection of the site having the antigen comprising a polypeptide of the invention for which the monoclonal antibodies are specific.

The concentration of detectably labeled monoclonal antibody which is administered should be sufficient such that the binding to those cells having the polypeptide is detectable compared to the background. Further, it is desirable that the detectably labeled monoclonal antibody be rapidly cleared from the circulatory system in order to give the best target-to-background signal ratio.

As a rule, the dosage of detectably labeled monoclonal antibody for in vivo diagnosis will vary depending on such factors as age, sex, and extent of disease of the individual. Such dosages may vary, for example, depending on whether multiple injections are given, antigenic burden, and other factors known to those of skill in the art.

For *in vivo* diagnostic imaging, the type of detection instrument available is a major factor in selecting a given radioisotope. The radioisotope chosen must have a type of decay which is detectable for a given type of instrument. Still another important factor in selecting a radioisotope for *in vivo* diagnosis is that deleterious radiation with respect to the host is minimized. Ideally, a radioisotope used for *in vivo* imaging will

lack a particle emission, but produce a large number of photons in the 140-250 keV range, which may readily be detected by conventional gamma cameras.

For *in vivo* diagnosis radioisotopes may be bound to immunoglobulin either directly or indirectly by using an intermediate functional group. Intermediate functional groups which often are used to bind radioisotopes which exist as metallic ions to immunoglobulins are the bifunctional chelating agents such as diethylenetriaminepentacetic acid (DTPA) and ethylenediaminetetraacetic acid (EDTA) and similar molecules. Typical examples of metallic ions which can be bound to the monoclonal antibodies of the invention are ^{111}In, ^{97}Ru, ^{67}Ga, ^{68}Ga, ^{72}As, ^{89}Zr, and ^{201}Tl.

The monoclonal antibodies of the invention can also be labeled with a paramagnetic isotope for purposes of *in vivo* diagnosis, as in magnetic resonance imaging (MRI) or electron spin resonance (ESR). In general, any conventional method for visualizing diagnostic imaging can be utilized. Usually gamma and positron emitting radioisotopes are used for camera imaging and paramagnetic isotopes for MRI. Elements which are particularly useful in such techniques include ^{157}Gd, ^{55}Mn, ^{162}Dy, ^{52}Cr, and ^{56}Fe.

The monoclonal antibodies or polynucleotides of the invention can be used *in vitro* and *in vivo* to monitor the course of amelioration of a FHF-1-associated disease in a subject. Thus, for example, by measuring the increase or decrease in the number of cells expressing antigen comprising a polypeptide of the invention or changes in the concentration of such antigen present in various body fluids, it would be possible to determine whether a particular therapeutic regimen aimed at ameliorating the FHF-1-associated disease is effective. The term "ameliorate" denotes a lessening of the detrimental effect of the FHF-1-associated disease in the subject receiving therapy.

The present invention identifies a nucleotide sequence that can be expressed in an altered manner as compared to expression in a normal cell, therefore it is possible to design appropriate therapeutic or diagnostic techniques directed to this sequence. Detection of elevated levels of FHF-1 expression is accomplished by hybridization of nucleic acids isolated from a cell suspected of having an FHF-1 associated proliferative disorder with an FHF-1 polynucleotide of the invention. Analysis, such

as Northern Blot analysis, are utilized to quantitate expression of FHF-1. Other standard nucleic acid detection techniques will be known to those of skill in the art.

Treatment of an FHF-1 associated cell proliferative disorder include modulation of FHF-1 gene expression and FHF-1 activity. The term "modulate" envisions the suppression of expression of FHF-1 when it is over-expressed, or augmentation of FHF-1 expression when it is under-expressed. Where a cell-proliferative disorder is associated with the expression of FHF-1, nucleic acid sequences that interfere with FHF-1 expression at the translational level can be used. This approach utilizes, for example, antisense nucleic acid, ribozymes, or triplex agents to block transcription or translation of a specific FHF-1 mRNA, either by masking that mRNA with an antisense nucleic acid or triplex agent, or by cleaving it with a ribozyme. Such disorders include neurodegenerative diseases, for example.

Antisense nucleic acids are DNA or RNA molecules that are complementary to at least a portion of a specific mRNA molecule (Weintraub, *Scientific American*, 262:40, 1990). In the cell, the antisense nucleic acids hybridize to the corresponding mRNA, forming a double-stranded molecule. The antisense nucleic acids interfere with the translation of the mRNA, since the cell will not translate a mRNA that is double-stranded. Antisense oligomers of about 15 nucleotides are preferred, since they are easily synthesized and are less likely to cause problems than larger molecules when introduced into the target FHF-1-producing cell. The use of antisense methods to inhibit the *in vitro* translation of genes is well known in the art (Marcus-Sakura, *Anal.Biochem.*, 172:289, 1988).

Use of an oligonucleotide to stall transcription is known as the triplex strategy since the oligomer winds around double-helical DNA, forming a three-strand helix. Therefore, these triplex compounds can be designed to recognize a unique site on a chosen gene (Maher, *et al., Antisense Res. and Dev.*, 1(3):227, 1991; Helene, C., *Anticancer Drug Design*, 6(6):569, 1991).

Ribozymes are RNA molecules possessing the ability to specifically cleave other single-stranded RNA in a manner analogous to DNA restriction endonucleases. Through the modification of nucleotide sequences which encode these RNAs, it is possible to engineer molecules that recognize specific nucleotide sequences in an

RNA molecule and cleave it (Cech, *J.Amer.Med. Assn.*, 260:3030, 1988). A major advantage of this approach is that, because they are sequence-specific, only mRNAs with particular sequences are inactivated.

There are two basic types of ribozymes namely, *tetrahymena*-type (Hasselhoff, *Nature*, 334:585, 1988) and "hammerhead"-type. *Tetrahymena*-type ribozymes recognize sequences which are four bases in length, while "hammerhead"-type ribozymes recognize base sequences 11-18 bases in length. The longer the recognition sequence, the greater the likelihood that the sequence will occur exclusively in the target mRNA species. Consequently, hammerhead-type ribozymes are preferable to *tetrahymena*-type ribozymes for inactivating a specific mRNA species and 18-based recognition sequences are preferable to shorter recognition sequences.

The present invention also provides gene therapy for the treatment of cell proliferative or immunologic disorders which are mediated by FHF-1 protein. Such therapy would achieve its therapeutic effect by introduction of the FHF-1 antisense polynucleotide into cells having the proliferative disorder. Delivery of antisense FHF-1 polynucleotide can be achieved using a recombinant expression vector such as a chimeric virus or a colloidal dispersion system. Especially preferred for therapeutic delivery of antisense sequences is the use of targeted liposomes.

Various viral vectors which can be utilized for gene therapy as taught herein include adenovirus, herpes virus, vaccinia, or, preferably, an RNA virus such as a retrovirus. Preferably, the retroviral vector is a derivative of a murine or avian retrovirus. Examples of retroviral vectors in which a single foreign gene can be inserted include, but are not limited to: Moloney murine leukemia virus (MoMuLV), Harvey murine sarcoma virus (HaMuSV), murine mammary tumor virus (MuMTV), and Rous Sarcoma Virus (RSV). Preferably, when the subject is a human, a vector such as the gibbon ape leukemia virus (GaLV) is utilized. A number of additional retroviral vectors can incorporate multiple genes. All of these vectors can transfer or incorporate a gene for a selectable marker so that transduced cells can be identified and generated. By inserting a FHF-1 sequence of interest into the viral vector, along with another gene which encodes the ligand for a receptor on a specific target cell, for example, the vector is now target specific. Retroviral vectors can be made target

specific by attaching, for example, a sugar, a glycolipid, or a protein. Preferred targeting is accomplished by using an antibody to target the retroviral vector. Those of skill in the art will know of, or can readily ascertain without undue experimentation, specific polynucleotide sequences which can be inserted into the retroviral genome or attached to a viral envelope to allow target specific delivery of the retroviral vector containing the FHF-1 antisense polynucleotide.

Since recombinant retroviruses are defective, they require assistance in order to produce infectious vector particles. This assistance can be provided, for example, by using helper cell lines that contain plasmids encoding all of the structural genes of the retrovirus under the control of regulatory sequences within the LTR. These plasmids are missing a nucleotide sequence which enables the packaging mechanism to recognize an RNA transcript for encapsidation. Helper cell lines which have deletions of the packaging signal include, but are not limited to Ψ2, PA317 and PA12, for example. These cell lines produce empty virions, since no genome is packaged. If a retroviral vector is introduced into such cells in which the packaging signal is intact, but the structural genes are replaced by other genes of interest, the vector can be packaged and vector virion produced.

Alternatively, NIH 3T3 or other tissue culture cells can be directly transfected with plasmids encoding the retroviral structural genes *gag, pol* and *env*, by conventional calcium phosphate transfection. These cells are then transfected with the vector plasmid containing the genes of interest. The resulting cells release the retroviral vector into the culture medium.

Another targeted delivery system for FHF-1 antisense polynucleotides is a colloidal dispersion system. Colloidal dispersion systems include macromolecule complexes, nanocapsules, microspheres, beads, and lipid-based systems including oil-in-water emulsions, micelles, mixed micelles, and liposomes. The preferred colloidal system of this invention is a liposome. Liposomes are artificial membrane vesicles which are useful as delivery vehicles *in vitro* and *in vivo*. It has been shown that large uni-lamellar vesicles (LUV), which range in size from 0.2-4.0 μm can encapsulate a substantial percentage of an aqueous buffer containing large macromolecules. RNA, DNA and intact virions can be encapsulated within the aqueous interior and be delivered to cells in a biologically active form (Fraley, *et al., Trends Biochem. Sci.*,

6:77, 1981). In addition to mammalian cells, liposomes have been used for delivery of polynucleotides in plant, yeast and bacterial cells. In order for a liposome to be an efficient gene transfer vehicle, the following characteristics should be present: (1) encapsulation of the genes of interest at high efficiency while not compromising their biological activity; (2) preferential and substantial binding to a target cell in comparison to non-target cells; (3) delivery of the aqueous contents of the vesicle to the target cell cytoplasm at high efficiency; and (4) accurate and effective expression of genetic information (Mannino, *et al.; Biotechniques*, 6:682, 1988).

The composition of the liposome is usually a combination of phospholipids, particularly high-phase-transition-temperature phospholipids, usually in combination with steroids, especially cholesterol. Other phospholipids or other lipids may also be used. The physical characteristics of liposomes depend on pH, ionic strength, and the presence of divalent cations.

Examples of lipids useful in liposome production include phosphatidyl compounds, such as phosphatidylglycerol, phosphatidylcholine, phosphatidylserine, phosphatidylethanolamine, sphingolipids, cerebrosides, and gangliosides. Particularly useful are diacylphosphatidylglycerols, where the lipid moiety contains from 14-18 carbon atoms, particularly from 16-18 carbon atoms, and is saturated. Illustrative phospholipids include egg phosphatidylcholine, dipalmitoylphosphatidylcholine and distearoylphosphatidylcholine.

The targeting of liposomes can be classified based on anatomical and mechanistic factors. Anatomical classification is based on the level of selectivity, for example, organ-specific, cell-specific, and organelle-specific. Mechanistic targeting can be distinguished based upon whether it is passive or active. Passive targeting utilizes the natural tendency of liposomes to distribute to cells of the reticulo-endothelial system (RES) in organs which contain sinusoidal capillaries. Active targeting, on the other hand, involves alteration of the liposome by coupling the liposome to a specific ligand such as a monoclonal antibody, sugar, glycolipid, or protein, or by changing the composition or size of the liposome in order to achieve targeting to organs and cell types other than the naturally occurring sites of localization.

The surface of the targeted delivery system may be modified in a variety of ways. In the case of a liposomal targeted delivery system, lipid groups can be incorporated into the lipid bilayer of the liposome in order to maintain the targeting ligand in stable association with the liposomal bilayer. Various linking groups can be used for joining the lipid chains to the targeting ligand.

Due to the expression of FHF-1 in the testes, eye and brain, or neural tissue, there are a variety of applications using the polypeptide, polynucleotide, and antibodies of the invention, related to these tissues. Such applications include treatment of cell proliferative and immunologic disorders involving these and other tissues. In addition, FHF-1 may be useful in various gene therapy procedures.

Due to the high level of expression of FHF-1 in the testes, there are a variety of applications using the polypeptide, polynucleotide, and antibodies of the invention related to this tissue. Such applications include treatment of cell proliferative disorders associated with FHF-1 expression in the testes. Various testicular developmental or acquired disorders can also be subject to FHF-1 applications. These may include, but are not limited to viral infection (*e.g.*, viral orchitis), autoimmunity, sperm production or dysfunction, trauma, and testicular tumors. The presence of high levels of FHF-1 in the testis suggests that FHF-1 or an analogue of FHF-1 could be used to increase or decrease male fertility.

The identification of a novel member of the FGF family provides a useful tool for diagnosis, prognosis and therapeutic strategies associated with FHF-1 mediated disorders. Measurement of FHF-1 levels using anti-FHF-1 antibodies is a useful diagnostic for following the progression or recovery from diseases of the nervous system, including: cancer, stroke, neurodegenerative diseases such as Parkinson's disease or Alzheimer's disease, retinal diseases such as retinitis pigmentosa, or viral encephalitis. The presence of high levels of FHF-1 in the central nervous system suggests that the observed low level of FHF-1 in a number of peripheral tissues could reflect FHF-1 in peripheral nerve, and therefore measurement of FHF-1 levels using anti-FHF-1 antibodies could be diagnostic for peripheral neuropathy. The presence of high levels of FHF-1 in the testis suggests that measurement of FHF-1 levels using anti-FHF-1 antibodies could be diagnostic for testicular cancer.

Like other members of the FGF family, FHF-1 likely has mitogenic and/or cell survival activity, therefore FHF-1 or an analogue that mimics FHF-1 action could be used to promote tissue repair or replacement. The presence of FHF-1 in the CNS suggests such a therapeutic role in diseases of the nervous system, including: stroke, neurodegenerative diseases such as Parkinson's disease or Alzheimer's disease, or in retinal degenerative diseases such as retinitis pigmentosa or macular degeneration, or in peripheral neuropathies. Conversely, blocking FHF-1 action either with anti-FHF-1 antibodies or with an FHF-1 antagonist might slow or ameliorate diseases in which excess cell growth is pathological, most obviously cancer.

The following examples are intended to illustrate but not limit the invention. While they are typical of those that might be used, other procedures known to those skilled in the art may alternatively be used.

EXAMPLE 1

IDENTIFICATION OF FHF-1, A NOVEL MEMBER OF THE FGF FAMILY

To identify novel gene products expressed in the human retina, random segments of human retina cDNA clones were partially sequenced, and the resulting partial sequences compared to the sequences available in the public databases.

In detail, an adult human retina cDNA library constructed in lambda gt10 (Nathans, *et al., Science* 232: 193, 1986) was amplified, and the cDNA inserts were excised en mass by cleavage with EcoR I and purified free of the vector by agarose gel electrophoresis. Following heat denaturation of the purified cDNA inserts, a synthetic oligonucleotide containing an EcoR I site at its 5' end and six random nucleotides at its 3' end (5' GACGAGATATTAGAATTCTACTCGNNNNNN) (SEQ ID NO:3) was used to prime two sequential rounds of DNA synthesis in the presence of the Klenow fragment of E. coli DNA polymerase. The resulting duplex molecules were amplified using the polymerase chain reaction (PCR) with a primer corresponding to the unique 5' flanking sequence (5' CCCCCCCCCGACGAGATATTAGAATTCTACTCG) (SEQ ID NO:4). These PCR products, representing a random sampling of the original cDNA inserts, were cleaved with EcoR I, size fractionated by preparative agarose gel electrophoresis to include only segments of approximately 500 bp in length, and

cloned into lambda gt10. Three thousand single plaques from this derivative library were arrayed in 96-well trays and from these clones the inserts were amplified by PCR using flanking vector primers and then sequenced using the dideoxy method and automated fluorescent detection (Applied Biosystems). A single sequencing run from one end of each insert was conceptually translated on both strands in all three reading frames and the six resulting amino acid sequences were used to search for homology in the GenBank nonredundant protein database using the BLASTX searching algorithm.

One partial cDNA sequence was found that showed statistically significant homology to previously described members of the FGF family. Using this partial cDNA as a probe, multiple independent cDNA clones were isolated from the human retina cDNA library, including two that encompass the entire open reading frame and from which complete nucleotide sequences were determined.

EXAMPLE 2

DEDUCED PRIMARY STRUCTURE OF FHF-1

Figure 1 shows the sequence of human FHF-1 deduced from the nucleotide sequences of two independent human retina cDNA clones. The primary translation product of human FHF-1 is predicted to be 244 amino acids in length. The human FHF-1 inititiator methionine codon shown in Figure 1 at position 332-334 is the first ATG codon following the in-frame stop codon at nucleotides 323-325; a good consensus ribosome binding site (CAGCTATGG (SEQ ID NO:5); Kozak, *Nucleic Acids Res.* 15: 8125, 1987) is found at this position. The next methionine codon within the open reading frame is encountered 86 codons 3' of the putative initiator methionine codon. As observed for aFGF and bFGF, the amino-terminus of the primary translation product of FHF-1 does not conform to the consensus sequence for a signal peptide to direct cotranslational insertion across the endoplasmic reticulum membrane. The FHF-1 sequence lacks asn-X-ser/thr sites for asparagine-linked glycosylation.

Alignment of FHF-1 with the other known members of the FGF family is shown in Figure 2 and a dendrogram showing the degree of amino acid similarity is shown in Figure 3. The most homologous FGF family member is FGF-9 which shows

27% amino acid identity with FHF-1 when aligned with 10 gaps. Note that in the central region of each polypeptide, all FGF family members, including FHF-1, share 11 invariant amino acids.

EXAMPLE 3

CHROMOSOMAL LOCALIZATION OF FHF-1

The chromosomal location of FHF-1 was determined by probing a Southern blot containing restriction enzyme digested DNA derived from a panel of 24 human-mouse and human-hamster cell lines, each containing a different human chromosome (Oncor, Gaithersburg, MD). As seen in Figure 4, hybridization of the human FHF-1 probe to human, mouse, and hamster genomic DNA produces distinct hybridizing fragment sizes. Among the hybrid panels, the human-specific hybridization pattern is seen only in the lane corresponding to the hybrid cell line carrying human chromosome 3.

EXAMPLE 4

PRODUCTION OF FHF-1 IN TRANSFECTED HUMAN CELLS

To express FHF-1 in human cells, the complete open reading frame was inserted into the eukaryotic expression vector pCIS (Gorman, *et al., DNA Protein Eng. Tech.* 2: 3, 1990). To increase the efficiency of translation, the region immediately 5' of the initiator methionine coding was converted to an optimal ribosome binding site (CCACC**ATG**G) by PCR amplification with a primer that carried the desired sequence. Following transient transfection of human embryonic kidney cells with the expression construct and a plasmid expressing the simian virus 40 (SV40) large T-antigen (pRSV-TAg; Gorman, *et al., supra*), cells were metabolically labeled with ^{35}S methionine for 6 hours in the absence of serum. As shown in Figure 5, cells transfected with FHF-1 synthesize a single abundant polypeptide with an apparent molecular mass of 30 kD that is not produced by cells transfected with either of two unrelated constructs. This polypeptide corresponds closely to the predicted molecular mass of the primary translation product, 27.4 kD. Figure 5 also shows that cells transfected with a human growth hormone (hGH) expression plasmid efficiently secrete hGH,

BNSDOCID: <WO___9635708A1_IA>

whereas FHF-1 accumulates within the transfected cells and fails to be secreted in detectable quantities.

EXAMPLE 5

TISSUE DISTRIBUTION OF FHF-1 mRNA

To determine the tissue distribution of FHF-1 mRNA, RNase protection analysis was performed on total RNA from mouse brain, eye, heart, kidney, liver, lung, spleen, and testis, as well as a yeast tRNA negative control. The probe used was derived from a segment of the mouse FHF-1 gene isolated by hybridization with the full-length human FHF-1 cDNA. As seen in Figure 6, the highest levels of FHF-1 expression are in the brain, eye, and testis. Very low levels of FHF-1 expression were detected in kidney, liver, and lung on a five-fold longer exposure of the autoradiogram.

EXAMPLE 6

PRODUCTION OF ANTIBODIES SPECIFIC FOR FHF-1

To generate anti-FHF-1 antibodies, a DNA segment encompassing the carboxy-terminal 190 amino acids of FHF-1 was inserted into the *E. coli* expression vector pGEMEX (Studier, *et al, Meth. Enzymol.* 185: 60, 1990). The recombinant fusion protein between the T7 gene 10 protein and the carboxy-terminal 190 amino acids of FHF-1 was produced in *E. coli*, purified by preparative polyacrylamide gel electrophoresis, and used to immunize rabbits. Anti-FHF-1 antibodies from immune serum were affinity purified using the fusion protein immobilized onto nitrocellulose; those antibodies directed against the pGEMEX T7 gene10 protein fusion partner were removed by absorption to the purified T7 gene 10 protein immobilized onto nitrocellulose. By Western blotting, the affinity purified anti-FHF-1 antibodies were shown to recognize recombinant FHF-1 produced either in *E. coli* or in human embryonic kidney cells. By immunohistochemical staining the antibodies also specifically recognized recombinant FHF-1 produced in human embryonic kidney cells transfected with the FHF-1 expression plasmid described above. Immunostaining of neural tissues shows anti-FHF-1 immunostaining in the ganglion cell layer and inner

nuclear layers of adult mouse and macaque monkey retinas and in a large number of regions within the adult mouse brain.

Although the invention has been described with reference to the presently preferred embodiment, it should be understood that various modifications can be made without departing from the spirit of the invention. Accordingly, the invention is limited only by the following claims.

SEQUENCE LISTING

(1) GENERAL INFORMATION:

(i) APPLICANT: The Johns Hopkins University School of Medicine

(ii) TITLE OF INVENTION: FIBROBLAST GROWTH FACTOR HOMOLOGOUS FACTOR-1 (FHF-1) AND METHODS OF USE

(iii) NUMBER OF SEQUENCES: 5

(iv) CORRESPONDENCE ADDRESS:
(A) ADDRESSEE: Fish & Richardson P.C.
(B) STREET: 4225 Executive Square, Suite 1400
(C) CITY: La Jolla
(D) STATE: CA
(E) COUNTRY: USA
(F) ZIP: 92037

(v) COMPUTER READABLE FORM:
(A) MEDIUM TYPE: Floppy disk
(B) COMPUTER: IBM PC compatible
(C) OPERATING SYSTEM: PC-DOS/MS-DOS
(D) SOFTWARE: PatentIn Release #1.0, Version #1.30

(vi) CURRENT APPLICATION DATA:
(A) APPLICATION NUMBER:
(B) FILING DATE: 10-MAY-1996
(C) CLASSIFICATION:

(viii) ATTORNEY/AGENT INFORMATION:
(A) NAME: Haile, Ph.D.Lisa A.
(B) REGISTRATION NUMBER: 38,347
(C) REFERENCE/DOCKET NUMBER: 07265/047WO1

(ix) TELECOMMUNICATION INFORMATION:
(A) TELEPHONE: 619/678-5070
(B) TELEFAX: 617/678-5099

(2) INFORMATION FOR SEQ ID NO:1:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 1422 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(VII) IMMEDIATE SOURCE:
(B) CLONE: FHF-1

(ix) FEATURE:
(A) NAME/KEY: CDS
(B) LOCATION: 332..1060

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

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GAATTCCGCA CACTGCGTTC GGGGTACCAA GTGGAAGGGG AAGAACGATG CCCAAAATAA      60

CAAGACGTGC CTGGGACCGC CCCGCCCCGC CCCCCGGCCG CCAGAGGTTG GGGAAGTTTA     120

CATCTGGATT TTCACACATT TTGTCGCCAC TGCCCAGACT TTGACTAACC TTGTGAGCGC     180

CGGGTTTTCG ATACTGCAGC CTCCTCAAAT TTTAGCACTG CCTCCCCGCG ACTGCCCTTT     240

CCCTGGCCGC CCAGGTCCTG CCCTCGCCCC GGCGGAGCGC AAGCCGGAGG GCGCAGTAGA     300

GGCTGGGGCC TGAGGCCCTC GCTGAGCAGC T ATG GCT GCG GCG ATA GCC AGC         352
                                    Met Ala Ala Ala Ile Ala Ser
                                     1               5

TCC TTG ATC CGG CAG AAG CGG CAG GCG AGG GAG TCC AAC AGC GAC CGA       400
Ser Leu Ile Arg Gln Lys Arg Gln Ala Arg Glu Ser Asn Ser Asp Arg
         10                  15                  20

GTG TCG GCC TCC AAG CGC CGC TCC AGC CCC AGC AAA GAC GGG CGC TCC       448
Val Ser Ala Ser Lys Arg Arg Ser Ser Pro Ser Lys Asp Gly Arg Ser
     25                  30                  35

CTG TGC GAG AGG CAC GTC CTC GGG GTG TTC AGC AAA GTG CGC TTC TGC       496
Leu Cys Glu Arg His Val Leu Gly Val Phe Ser Lys Val Arg Phe Cys
 40                  45                  50                  55

AGC GGC CGC AAG AGG CCG GTG AGG CGG AGA CCA GAA CCC CAG CTC AAA       544
Ser Gly Arg Lys Arg Pro Val Arg Arg Arg Pro Glu Pro Gln Leu Lys
                 60                  65                  70

GGG ATT GTG ACA AGG TTA TTC AGC CAG CAG GGA TAC TTC CTG CAG ATG       592
Gly Ile Val Thr Arg Leu Phe Ser Gln Gln Gly Tyr Phe Leu Gln Met
             75                  80                  85

CAC CCA GAT GGT ACC ATT GAT GGG ACC AAG GAC GAA AAC AGC GAC TAC       640
His Pro Asp Gly Thr Ile Asp Gly Thr Lys Asp Glu Asn Ser Asp Tyr
         90                  95                 100

ACT CTC TTC AAT CTA ATT CCC GTG GGC CTG CGT GTA GTG GCC ATC CAA       688
Thr Leu Phe Asn Leu Ile Pro Val Gly Leu Arg Val Val Ala Ile Gln
     105                 110                 115

GGA GTG AAG GCT AGC CTC TAT GTG GCC ATG AAT GGT GAA GGC TAT CTC       736
Gly Val Lys Ala Ser Leu Tyr Val Ala Met Asn Gly Glu Gly Tyr Leu
120                 125                 130                 135

TAC AGT TCA GAT GTT TTC ACT CCA GAA TGC AAA TTC AAG GAA TCT GTG       784
Tyr Ser Ser Asp Val Phe Thr Pro Glu Cys Lys Phe Lys Glu Ser Val
                140                 145                 150

TTT GAA AAC TAC TAT GTG ATC TAT TCT TCC ACA CTG TAC CGC CAG CAA       832
Phe Glu Asn Tyr Tyr Val Ile Tyr Ser Ser Thr Leu Tyr Arg Gln Gln
            155                 160                 165
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GAA TCA GGC CGA GCT TGG TTT CTG GGA CTC AAT AAA GAA GGT CAA ATT 880
Glu Ser Gly Arg Ala Trp Phe Leu Gly Leu Asn Lys Glu Gly Gln Ile
170 175 180

ATG AAG GGG AAC AGA GTG AAG AAA ACC AAG CCC TCA TCA CAT TTT GTA 928
Met Lys Gly Asn Arg Val Lys Lys Thr Lys Pro Ser Ser His Phe Val
185 190 195

CCG AAA CCT ATT GAA GTG TGT ATG TAC AGA GAA CCA TCG CTA CAT GAA 976
Pro Lys Pro Ile Glu Val Cys Met Tyr Arg Glu Pro Ser Leu His Glu
200 205 210 215

ATT GGA GAA AAA CAA GGG CGT TCA AGG AAA AGT TCT GGA ACA CCA ACC 1024
Ile Gly Glu Lys Gln Gly Arg Ser Arg Lys Ser Ser Gly Thr Pro Thr
220 225 230

ATG AAT GGA GGC AAA GTT GTG AAT CAA GAT TCA ACA TAGCTGAGAA 1070
Met Asn Gly Gly Lys Val Val Asn Gln Asp Ser Thr
235 240

CTCTCCCCTT CTTCCCTCTC TCATCCCTTC CCCTTCCCTT CCTTCCCATT TACCCATTTC 1130

CTTCCAGTAA ATCCACCCAA GGAGAGGAAA ATAAAATGAC AACGCAAGAC CTAGTGGCTA 1190

AGATTCTGCA CTCAAAATCT TCCTTTGTGT AGGACAAGAA AATTGAACCA AAGCTTGCTT 1250

GTTGCAATGT GGTAGAAAAT TCACGTGCAC AAAGATTAGC ACACTTAAAA GCAAAGGAAA 1310

AAATAAATCA GAACTCCATA AATATTAAAC TAAACTGTAT TGTTATTAGT AGAAGGCTAA 1370

TTGTAATGAA GACATTAATA AAGATGAAAT AAACTTATTA CTTTCGGAAT TC 1422

(2) INFORMATION FOR SEQ ID NO:2:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 243 amino acids
(B) TYPE: amino acid
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

Met Ala Ala Ala Ile Ala Ser Ser Leu Ile Arg Gln Lys Arg Gln Ala
1 5 10 15

Arg Glu Ser Asn Ser Asp Arg Val Ser Ala Ser Lys Arg Arg Ser Ser
20 25 30

Pro Ser Lys Asp Gly Arg Ser Leu Cys Glu Arg His Val Leu Gly Val
35 40 45

Phe Ser Lys Val Arg Phe Cys Ser Gly Arg Lys Arg Pro Val Arg Arg
50 55 60

Arg Pro Glu Pro Gln Leu Lys Gly Ile Val Thr Arg Leu Phe Ser Gln
65 70 75 80

Gln Gly Tyr Phe Leu Gln Met His Pro Asp Gly Thr Ile Asp Gly Thr
85 90 95

Lys Asp Glu Asn Ser Asp Tyr Thr Leu Phe Asn Leu Ile Pro Val Gly
100 105 110

Leu Arg Val Val Ala Ile Gln Gly Val Lys Ala Ser Leu Tyr Val Ala
115 120 125

Met Asn Gly Glu Gly Tyr Leu Tyr Ser Ser Asp Val Phe Thr Pro Glu
130 135 140

Cys Lys Phe Lys Glu Ser Val Phe Glu Asn Tyr Tyr Val Ile Tyr Ser
145 150 155 160

Ser Thr Leu Tyr Arg Gln Gln Glu Ser Gly Arg Ala Trp Phe Leu Gly
165 170 175

Leu Asn Lys Glu Gly Gln Ile Met Lys Gly Asn Arg Val Lys Lys Thr
180 185 190

Lys Pro Ser Ser His Phe Val Pro Lys Pro Ile Glu Val Cys Met Tyr
195 200 205

Arg Glu Pro Ser Leu His Glu Ile Gly Glu Lys Gln Gly Arg Ser Arg
210 215 220

Lys Ser Ser Gly Thr Pro Thr Met Asn Gly Gly Lys Val Val Asn Gln
225 230 235 240

Asp Ser Thr

(2) INFORMATION FOR SEQ ID NO:3:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 30 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

GACGAGATAT TAGAATTCTA CTCGNNNNNN

(2) INFORMATION FOR SEQ ID NO:4:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 33 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

BNSDOCID: <WO___9635708A1_IA>

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

CCCCCCCCCG ACGAGATATT AGAATTCTAC TCG 33

(2) INFORMATION FOR SEQ ID NO:5:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 9 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

CAGCTATGG 9

CLAIMS

1. Substantially pure fibroblast growth factor homologous factor-1 (FHF-1) characterized by:
   a. having a molecular weight of about 30kD as determined by reducing SDS-PAGE; and
   b. having essentially the amino acid sequence of SEQ ID NO:2.

2. An isolated polynucleotide sequence encoding the FHF-1 polypeptide of claim 1.

3. The polynucleotide of claim 2, wherein the FHF-1 nucleotide sequence is selected from the group consisting of:
   a. SEQ ID NO:1, wherein T can also be U;
   b. nucleic acid sequences complementary to SEQ ID NO:1;
   c. fragments of a. or b. that are at least 15 bases in length and that will selectively hybridize to DNA which encodes the FHF-1 protein of SEQ ID NO:2, under stringent conditions.

4. The polynucleotide sequence of claim 2, wherein the polynucleotide is isolated from a mammalian cell.

5. The polynucleotide of claim 4, wherein the mammalian cell is a human cell.

6. An expression vector including the polynucleotide of claim 2.

7. The vector of claim 6, wherein the vector is a plasmid.

8. The vector of claim 6, wherein the vector is a virus.

9. A host cell stably transformed with the vector of claim 6.

10. The host cell of claim 9, wherein the cell is prokaryotic.

11. The host cell of claim 9, wherein the cell is eukaryotic.

12. An antibody that binds to FHF-1 polypeptide or immunoreactive fragments thereof.

13. The antibody of claim 12, wherein the antibody is polyclonal.

14. The antibody of claim 12, wherein the antibody is monoclonal.

15. A method of detecting a cell proliferative disorder comprising contacting a specimen of a subject suspected of having a FHF-1 associated cell proliferative disorder with a reagent that binds to FHF-1 and detecting binding of the reagent to FHF-1.

16. The method of claim 15, wherein the cell is selected from the group consisting of brain, testes or eye cell.

17. The method of claim 15, wherein the reagent is an antibody which binds to FHF-1.

18. The method of claim 15, wherein the reagent is a polynucleotide which encodes FHF-1 polypeptide, or fragments thereof.

19. The method of claim 15, wherein the detecting is *in vivo*.

20. The method of claim 15, wherein the detection is *in vitro*.

21. The method of claim 17 or 18, wherein the reagent is detectably labeled.

22. The method of claim 21, wherein the detectable label is selected from the group consisting of a radioisotope, a fluorescent compound, a bioluminescent compound and a chemiluminescent compound.

23. A method of treating a cell proliferative disorder associated with expression of FHF-1, comprising contacting the cell having or suspected of having the disorder with a reagent which suppresses the FHF-1 activity.

24. The method of claim 23, wherein the reagent is an anti-FHF-1 antibody.

25. The method of claim 23, wherein the reagent is a FHF-1 antisense sequence.

26. The method of claim 23, wherein the cell is a testes, brain or eye cell.

27. The method of claim 23, wherein the reagent which suppresses FHF-1 activity is introduced to the cell using a vector.

28. The method of claim 27, wherein the vector is a colloidal dispersion system.

29. The method of claim 28, wherein the colloidal dispersion system is a liposome.

30. The method of claim 29, wherein the liposome is essentially target specific.

31. The method of claim 30, wherein the liposome is anatomically targeted.

32. The method of claim 30, wherein the liposome is mechanistically targeted.

33. The method of claim 32, wherein the mechanistic targeting is passive.

34. The method of claim 32, wherein the mechanistic targeting is active.

35. The method of claim 34, wherein the liposome is actively targeted by coupling with a moiety selected from the group consisting of a sugar, a glycolipid, and a protein.

36. The method of claim 35, wherein the protein moiety is an antibody.

37. The method of claim 27, wherein the vector is a virus.

38. The method of claim 37, wherein the virus is an RNA virus.

39. The method of claim 38, wherein the RNA virus is a retrovirus.

40. The method of claim 39, wherein the retrovirus is essentially target specific.

```
GAATTCCGCA CACTGCGTTC GGGGTACCAA GTGGAAGGGG AAGAACGATG CCCAAAATAA 60

CAAGACGTGC CTGGGACCGC CCCGCCCCGC CCCCCGGCCG CCAGAGGTTG GGGAAGTTTA 120

CATCTGGATT TTCACACATT TTGTCGCCAC TGCCCAGACT TTGACTAACC TTGTGAGCGC 180

CGGGTTTTCG ATACTGCAGC CTCCTCAAAT TTTAGCACTG CCTCCCCGCG ACTGCCCTTT 240

CCCTGGCCGC CCAGGTCCTG CCCTCGCCCC GGCGGAGCGC AAGCCGGAGG GCGCAGTAGA 300

GGCTGGGGCC TGAGGCCCTC GCTGAGCAGC TATGGCTGCG GCGATAGCCA GCTCCTTGAT 360
                                 M  A  A  A  I  A  S  S  L  I

CCGGCAGAAG CGGCAGGCGA GGGAGTCCAA CAGCGACCGA GTGTCGGCCT CCAAGCGCCG 420
 R  Q  K  R  Q  A  R  E  S  N  S  D  R  V  S  A  S  K  R  R

CTCCAGCCCC AGCAAAGACG GGCGCTCCCT GTGCGAGAGG CACGTCCTCG GGGTGTTCAG 480
 S  S  P  S  K  D  G  R  S  L  C  E  R  H  V  L  G  V  F  S

CAAAGTGCGC TTCTGCAGCG GCCGCAAGAG GCCGGTGAGG CGGAGACCAG AACCCCAGCT 540
 K  V  R  F  C  S  G  R  K  R  P  V  R  R  R  P  E  P  Q  L

CAAAGGGATT GTGACAAGGT TATTCAGCCA GCAGGGATAC TTCCTGCAGA TGCACCCAGA 600
 K  G  I  V  T  R  L  F  S  Q  Q  G  Y  F  L  Q  M  H  P  D

TGGTACCATT GATGGGACCA AGGACGAAAA CAGCGACTAC ACTCTCTTCA ATCTAATTCC 660
 G  T  I  D  G  T  K  D  E  N  S  D  Y  T  L  F  N  L  I  P

CGTGGGCCTG CGTGTAGTGG CCATCCAAGG AGTGAAGGCT AGCCTCTATG TGGCCATGAA 720
 V  G  L  R  V  V  A  I  Q  G  V  K  A  S  L  Y  V  A  M  N

TGGTGAAGGC TATCTCTACA GTTCAGATGT TTTCACTCCA GAATGCAAAT TCAAGGAATC 780
 G  E  G  Y  L  Y  S  S  D  V  F  T  P  E  C  K  F  K  E  S

TGTGTTTGAA AACTACTATG TGATCTATTC TTCCACACTG TACCGCCAGC AAGAATCAGG 840
 V  F  E  N  Y  Y  V  I  Y  S  S  T  L  Y  R  Q  Q  E  S  G

CCGAGCTTGG TTTCTGGGAC TCAATAAAGA AGGTCAAATT ATGAAGGGGA ACAGAGTGAA 900
 R  A  W  F  L  G  L  N  K  E  G  Q  I  M  K  G  N  R  V  K

GAAAACCAAG CCCTCATCAC ATTTTGTACC GAAACCTATT GAAGTGTGTA TGTACAGAGA 960
 K  T  K  P  S  S  H  F  V  P  K  P  I  E  V  C  M  Y  R  E

ACCATCGCTA CATGAAATTG GAGAAAAACA AGGGCGTTCA AGGAAAAGTT CTGGAACACC 1020
 P  S  L  H  E  I  G  E  K  Q  G  R  S  R  K  S  S  G  T  P

AACCATGAAT GGAGGCAAAG TTGTGAATCA AGATTCAACA TAGCTGAGAA CTCTCCCCTT 1080
 T  M  N  G  G  K  V  V  N  Q  D  S  T

CTTCCCTCTC TCATCCCTTC CCCTTCCCTT CCTTCCCATT TACCCATTTC CTTCCAGTAA 1140

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GGTAGAAAAT TCACGTGCAC AAAGATTAGC ACACTTAAAA GCAAAGGAAA AAATAAATCA 1320

GAACTCCATA AATATTAAAC TAAACTGTAT TGTTATTAGT AGAAGGCTAA TTGTAATGAA 1380

GACATTAATA AAGATGAAAT AAACTTATTA CTTTCGGAAT TC
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FIG. 1

BNSDOCID: <WO___9635708A1_IA>

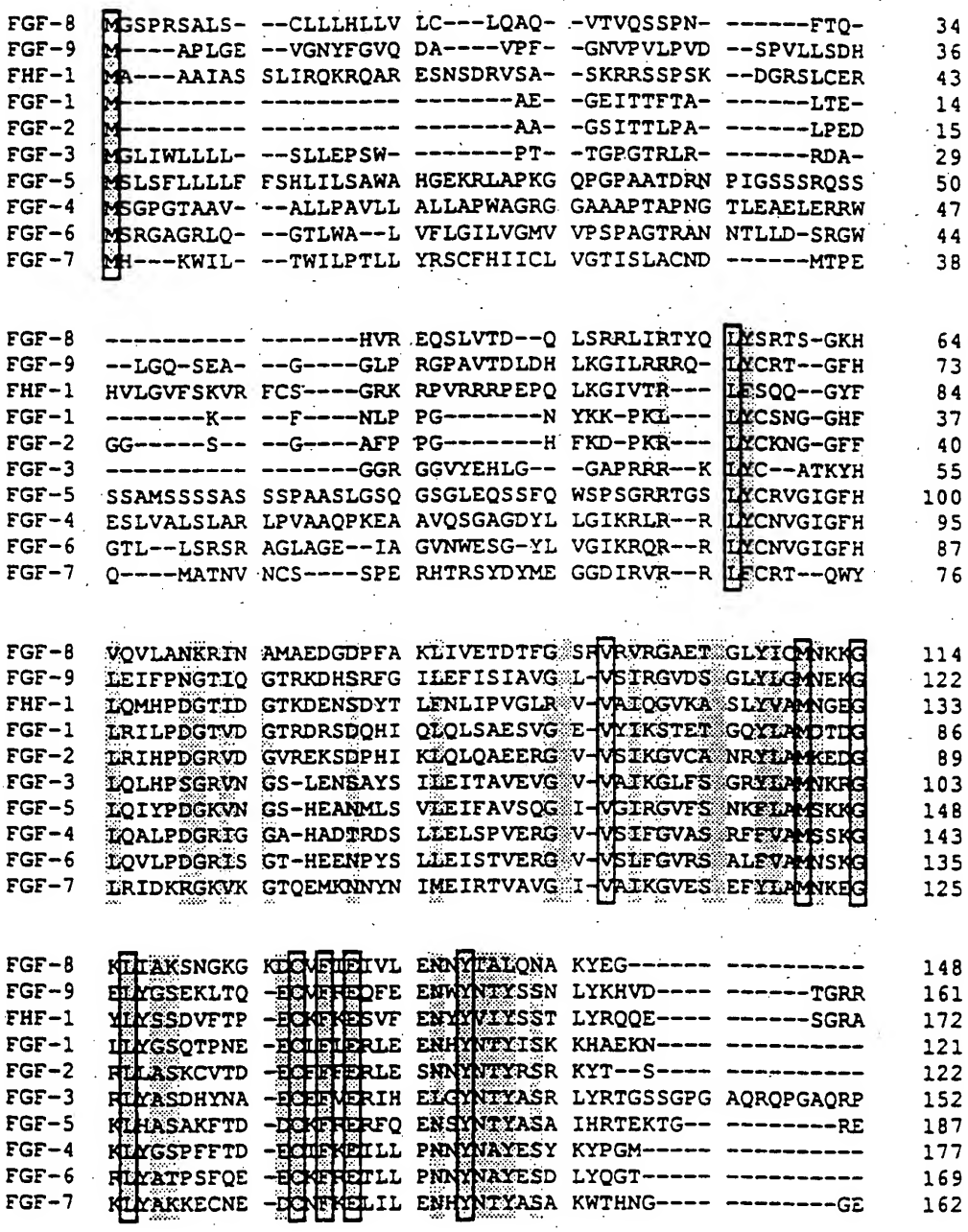

FIG. 2

```
FGF-8  WYMAFTRKGR PRKGSKTRQH QREVHFMKRL PRGHHTTEQS L---------  189
FGF-9  YYVALNKDGT PREGTRTKRH QKFTHFLPRP VD--------- ----------  193
FHF-1  WFLGLNKEGQ IMKGNRVKKT KPSSHFVPKP IEVC------ ----------  206
FGF-1  WFVGLKKNGS CKRGPRTHYG QKAILFLPLP VS--------- ----------  153
FGF-2  WYVALKRTGQ YKLGSKTGPG QKAILFLPMS AKS------- ----------  155
FGF-3  WYVSVNGKGR PRRGFKTRRT QKSSLFLPRV LGHKDHEMVR LLQSSQPRAP  202
FGF-5  WYVALNKRGK AKRGCSPR-- VK-----PQH IS--THFLPR FKQSEQPELS  228
FGF-4  -FIALSKNGK TKKGNRVS-- -------PTM KV--THFLPR L---------  206
FGF-6  -YIALSKYGR VKRGSKVS-- -------PIM TV--THFLPR I---------  198
FGF-7  MFVALNQKGI PVRGKKTKKE QKTAHFLPMA IT--------- ----------  194

FGF-8  ---------- -------RFE FLNYPPFTRS LRGSQRTWAP EPR         215
FGF-9  ---------- P------DK- --------VP ELYKD-ILSQ S--         208
FHF-1  ------MYRE PSLHEIGEKQ GRSRKSSGTP TMNGGKVVNQ DST         243
FGF-1  ---------- ---------- ---------- --------SD ---         155
FGF-2  ---------- ---------- ---------- ---------- ---         155
FGF-3  GEGSQPRQRR QKKQSPGDHG KMETLSTRAT PSTQLHTGGL AVA         245
FGF-5  FTVTVP---E KKNPPSPIKS KIPLSAPRKN TNSVKYRLKF RFG         268
FGF-4  ---------- ---------- ---------- ---------- ---         206
FGF-6  ---------- ---------- ---------- ---------- ---         198
FGF-7  ---------- ---------- ---------- ---------- ---         194
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FIG. 2

BNSDOCID: <WO___9635708A1_IA>

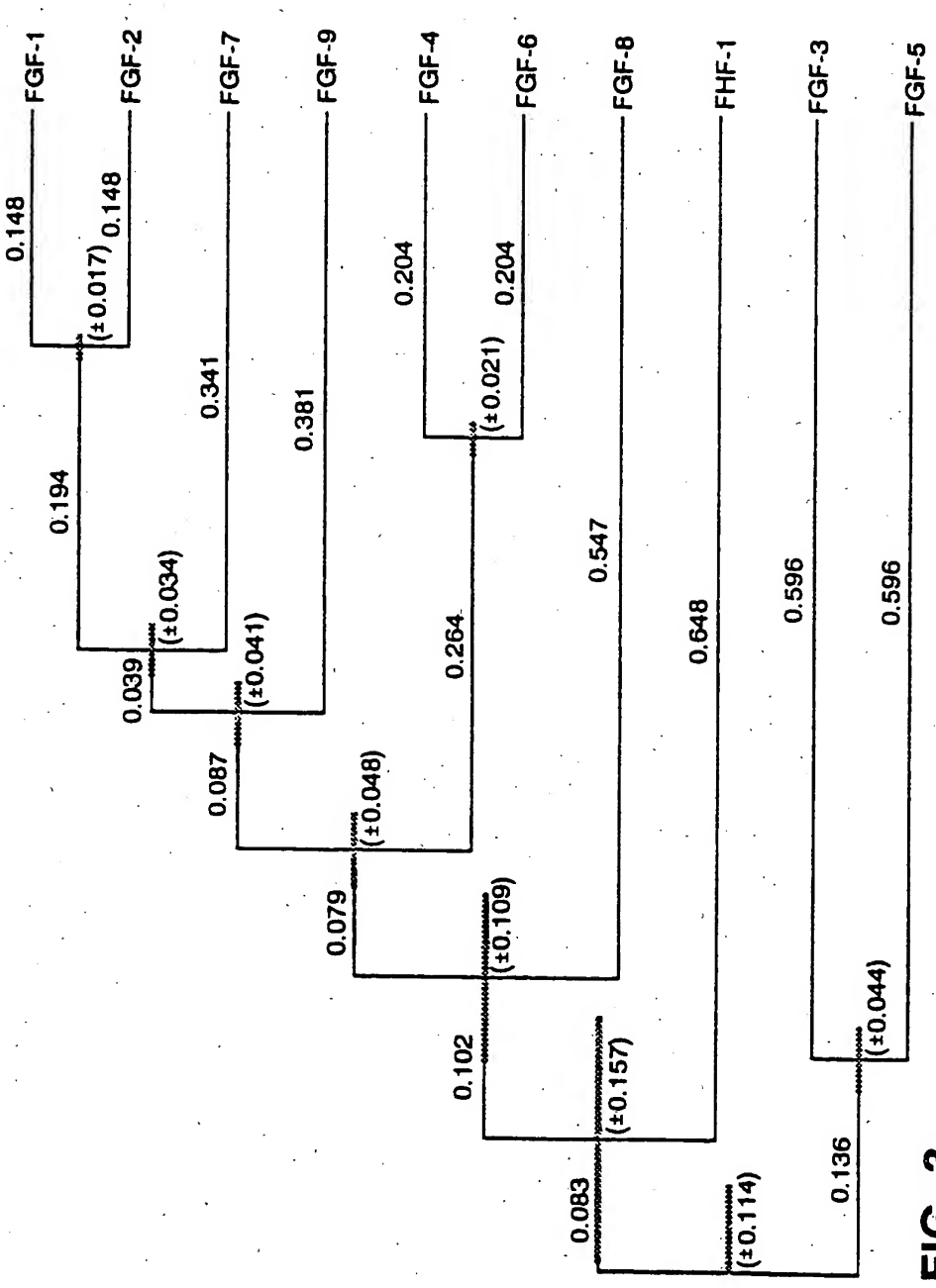
FGF-1
FGF-2
FGF-7
FGF-9
FGF-4
FGF-6
FGF-8
FHF-1
FGF-3
FGF-5
0.148
0.148
(±0.017)
0.194
0.341
0.039
(±0.034)
0.381
(±0.041)
0.087
0.204
0.204
(±0.021)
(±0.048)
0.264
0.079
0.547
(±0.109)
0.102
0.596
0.596
(±0.157)
0.648
0.083
(±0.114)
0.136
(±0.044)

FIG. 3

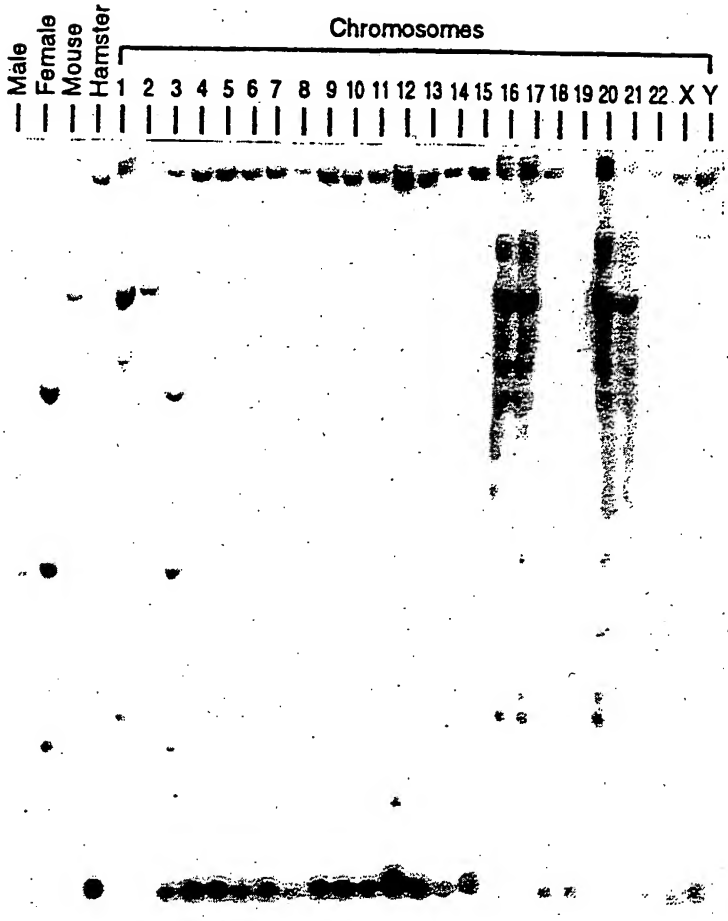

FIG. 4

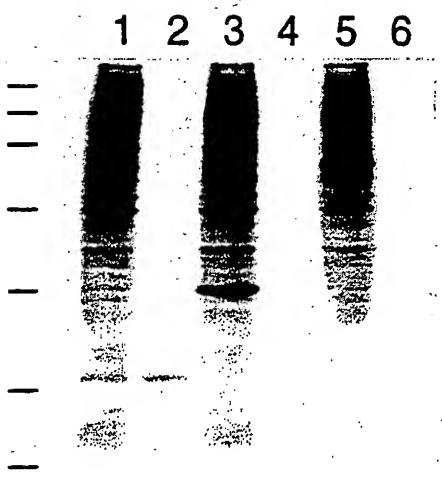

FIG. 5

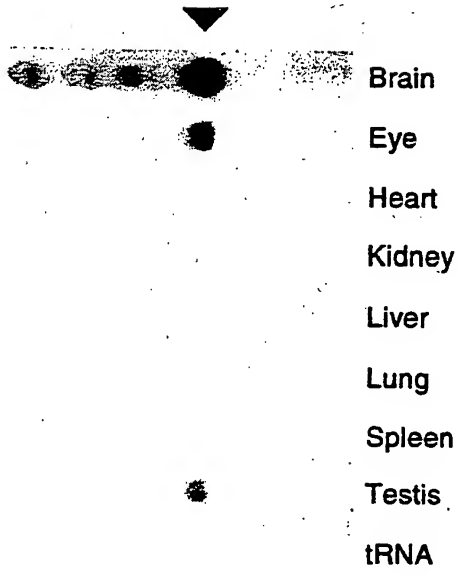

FIG. 6

BNSDOCID: <WO___9635708A1_IA>

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/06664

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :Please See Extra Sheet.
US CL : 530/350; 536/22.1, 23.1; 435/7.1; 514/44
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 530/350; 536/22.1, 23.1; 435/7.1; 514/44

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS, MEDLINE, CAPLUS, WPIDS
search terms: fibroblast growth factor, homologous

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	IIDA et al. Human hst-2 (FGF-6) oncogene: cDNA cloning and characterization. Oncogene. July 1992, Vol.7, pages 303-309, see the entire document.	1-11, 15-16, and 18-22
A	MIYAMOTO et al. Molecular cloning of a novel cytokine cDNA encoding the ninth member of the fibroblast growth factor family, which has a unique secretion property. Molecular and Cellular Biology. July 1993, Vol. 13, No. 7, pages 4251-4259, see the entire document.	1-11, 15-16, and 18-22
A	ZHAN et al. The human FGF-5 Oncogene encodes a novel protein related to fibroblast growth factors. Molecular and Cellular Biology. August 1988, Vol. 8, No. 8, pages 3487-3495, see the entire document .	1-11, 15-16, and 18-22

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
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Date of the actual completion of the international search 01 JULY 1996	Date of mailing of the international search report 23 JUL 1996
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer ETHAN WHISENANT Telephone No. (703) 308-0196

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/06664

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	MERLO et al. The mouse int-2 gene exhibits basic fibroblast growth factor activity in basci fibroblast growth factor-responsive cell lines. Cell Growth & Differentiation. October 1990. Vol. 1, pages 463-472, see the entire document.	1-11, 15-16, and 18-22
A	BROOKES et al. The mouse homologue of hst/k-FGF:sequence, genome organization and location relative to int-2. Nucleic Acids Research. November 1989. Vol. 17, No. 11, pages 4037-4045, see the entire document.	1-11, 15-16, and 18-22
A	YOSHIDA et al. Genomic sequence of hst, a transforming gene encoding a protein homologous to fibroblast growth factors and the int-2-encoded protein. Proc. Natl. Acad. Sci., USA. October 1987. Vol.84, pages 7305-7309, see the entire documment.	1-11, 15-16, and 18-22
A	PAYSON et al. Cloning of two novel forms of human acidic fibroblast growth factor (aFGF) mRNA. Nucleic Acids Research. March 1993, Vol. 21, No. 3, pages 489-495.	1-11, 15-16, and 18-22

BNSDOCID: <WO___9635708A1_IA>

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/06664

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-11, 15-16, and 18-22

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/06664

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (6):

C07K 1/00,14/00, 17/00; C07H 19/00, 21/00, 21/02, 21/04; A01N 43/04; A61 K 31/70; G01N 33/53

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claim(s) 1-11, 15-16, and 18-22, drawn to fibroblast growth factor homologous factor-1 (FHF-1), a polynucleotide sequence encoding FHF-1, and a method of detecting a cell proliferative disorder.

Group II, claim(s) 12-14,drawn to antibodies against FHF-1.

Group III, claim(s) 15-17 and 19-22, drawn to a method of detecting a cell proliferative disorder using antibodies against FHF-1.

Group IV, claim(s) 23-40, drawn to a method of treating an FHF-1 associated cell proliferative disorder.

The inventions listed as Groups I, II, III, and IV do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: (See MPEP 1875.01) The claims are drawn to two products and three processes of use. In this case Group I contains one product and a process of using said product. Group II contains a second product, while GroupIII contains a process of using this second product. Group IV contains a third process of use. The inventions are linked by a special technical feature (i.e. FHF-1), however, under 37 CFR 1.475(b)and(d) the category first mentioned in the claims, and the first recited invention of each of the other categories related thereto will be considered as the main invention.

BNSDOCID: <WO___9635708A1_IA>

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
C07K 1/00, 14/00, 17/00, C07H 19/00, 21/00, 21/02, 21/04, A01N 43/04, A61K 31/70, G01N 33/53

A1

(11) International Publication Number: WO 96/35708

(43) International Publication Date: 14 November 1996 (14.11.96)

(21) International Application Number: PCT/US96/06664

(22) International Filing Date: 10 May 1996 (10.05.96)

(30) Priority Data:
08/439,725 12 May 1995 (12.05.95) US

(71) Applicant: THE JOHNS HOPKINS UNIVERSITY SCHOOL OF MEDICINE [US/US]; 720 Rutland Avenue, Baltimore, MD 21205 (US).

(72) Inventors: NATHANS, Jeremy; 5510 South Bend Road, Baltimore, MD 21209 (US). SMALLWOOD, Philip, M.; 5022 Woodbine Road, Woodbine, MD 21297 (US). MACKE, Jennifer, P.; 7180 Talisman Road, Columbia, MD 21045 (US).

(74) Agent: HAILE, Lisa, A.; Fish & Richardson P.C., Suite 1400, 4225 Executive Square, La Jolla, CA 92037 (US).

(81) Designated States: AU, CA, JP, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: FIBROBLAST GROWTH FACTOR HOMOLOGOUS FACTOR-1 (FHF-1) AND METHODS OF USE

(57) Abstract

A novel protein, fibroblast growth factor homologous factor-1 (FHF-1), the polynucleotide sequence encoding FHF-1, and the deduced amino acid sequence are disclosed. Also disclosed are diagnostic and therapeutic methods of using the FHF-1 polypeptide and polynucleotide sequences and antibodies which specifically bind to FHF-1.

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BNSDOCID: <WO___9635708A1_I_>

FIBROBLAST GROWTH FACTOR HOMOLOGOUS FACTOR-1 (FHF-1) AND METHODS OF USE

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The invention relates generally to growth factors and specifically to a novel member of the fibroblast growth factor family, denoted fibroblast growth factor homologous factor-1 (FHF-1) and the polynucleotide encoding FHF-1.

2. DESCRIPTION OF RELATED ART

The fibroblast growth factor family encompasses a group of structurally related proteins with a wide range of growth promoting, survival, and/or differentiation activities in vivo and in vitro (reviewed in Baird, A., and Gospodarowicz, D. *Ann N.Y. Acad. Sci.* 638: 1, 1991; Eckenstein, F.P., *J. Neurobiology* 25: 1467, 1994; Mason, I.J. *Cell* 78: 547, 1994). As of December 1994, nine members of this family had been characterized by molecular cloning. The first two members of the family to be characterized, acidic fibroblast growth factor (aFGF/FGF-1) and basic fibroblast growth factor (bFGF/FGF-2), have been found in numerous tissues, including for example brain, eye, kidney, placenta, and adrenal (Jaye *et al., Science* 233: 541, 1986; Abraham *et al., Science* 233: 545, 1986). These factors have been shown to be potent mitogens and survival factors for a variety of mesoderm and neurectoderm-derived tissues, including fibroblasts, endothelial cells, hippocampal and cerebral cortical neurons, and astroglia (Burgess, W. H. and Maciag, T., *Ann. Rev. Biochemistry* 58: 575, 1989). Additional members of the FGF family include: int-2/FGF-3, identified as one of the frequent sites of integration of the mouse mammary tumor virus, and therefore a presumptive oncogenic factor (Smith *et al., EMBO J.* 7: 1013, 1988); FGF-4 (Delli-Bovi *et al., Cell* 50: 729, 1987) and FGF-5 (Zhan *et al., Mol. Cell Biol.*8: 3487, 1988) as transforming genes in the NIH 3T3 transfection assay; FGF-6, isolated by molecular cloning based on its homology to FGF-4 (Marics *et al., Oncogene* 4: 335 (1989); keratinocyte growth factor/ FGF-7, identified as a mitogen for keratinocytes (Finch *et al., Science* 245: 752, 1989); FGF-8 as an androgen-induced mitogen for mammary carcinoma cells (Tanaka *et*

al., Proc. Natl. Acad. Sci. USA 89: 8928, 1992); and FGF-9 as a mitogen for primary astrocytes (Miyamoto *et al., Mol. Cell Biol.* 13: 4251, 1993). Several of the FGFs, including aFGF and bFGF, lack a classical signal sequence; the mechanism by which they are secreted is not known.

All members of the FGF family share approximately 25% or more amino acid sequence identity, a degree of homology indicating that they are likely to share nearly identical three-dimensional structures. Support for this inference comes from a comparison of the three-dimensional structures of bFGF and interleukin 1-beta determined by x-ray diffraction (Eriksson *et al., Proc. Natl. Acad. Sci USA* 88: 3441, 1991; Zhang *et al., Proc. Natl. Acad. Sci USA* 88: 3446, 1991; Ago *et al., J. Biochem.* 110: 360, 1991). Although these proteins share only 10% amino acid identity, the alpha carbon backbones of the two crystal structures can be superimposed with a root-mean square deviation of less than 2 angstroms (Zhang *et al., Proc. Natl. Acad. Sci USA* 88: 3446, 1991). Both proteins consist almost entirely of beta-sheets, which form a barrel composed of three copies of a four-stranded beta-meander motif. The likely heparin- and receptor-binding regions are located on nearby regions on one face of the protein.

aFGF, bFGF, and FGF-7/KGF have been shown to exert some or all of their biological activity through high affinity binding to cell surface tyrosine kinase receptors (*e.g.*, Lee, P. L., *et al., Science* 245: 57, 1989; reviewed in Johnson, D.E. and Williams, L.T., *Adv. Cancer Res.* 60: 1, 1993). Many members of the FGF family also bind tightly to heparin, and a terniary complex of heparin, FGF, and transmembrane receptor may be the biologically relevant signalling species. Thus far four different genes have been identified that encode receptors for FGF family members. Recent work has shown that receptor diversity is increased by differential mRNA splicing within the extracellular ligand binding domain, with the result that multiple receptor isoforms with different ligand binding properties can be encoded by the same gene (Johnson, D.E. and Williams, L.T., *Adv. Cancer Res.* 60: 1, 1993). In tissue culture systems, the binding of aFGF or bFGF to its cell surface receptor activates phospholipase C-gamma (Burgess, W. H. *et al., Mol. Cell Biol.* 10: 4770, 1990), a pathway known to integrate a variety of mitogenic signals.

Identification and characterization of new members of the FGF family will provide insights into the mechanisms by which cells and organs control their growth, survival, senescence, differentiation, and recovery from injury.

SUMMARY OF THE INVENTION

The present invention provides a cell growth, survival or differentiation factor, FHF-1 and a polynucleotide sequence which encodes the factor. This factor is involved in the growth, survival, and or differentiation of cells within the central nervous system (CNS) as well as in peripheral tissues.

The invention provides a method for detecting alterations in FHF-1 gene expression which are diagnostic of neurodegenerative or neoplastic disorders. In another embodiment, the invention provides a method for treating a neurodegenerative or neoplastic disorder by modulating the expression or activity of FHF-1.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows the nucleotide and predicted amino acid sequence of human FHF-1.

Figure 2 shows the alignment of the amino acid sequence of human FHF-1 and each of the other nine members of the FGF family. Conserved residues are highlighted. The FGF family members are: aFGF/FGF-1 (Jaye *et al., Science* 233: 541, 1986), bFGF/FGF-2 (Abraham *et al., Science* 233: 545, 1986), int-2/FGF-3 (Smith *et al., EMBO J.* 7: 1013, 1988), FGF-4 (Delli-Bovi *et al., Cell* 50: 729, 1987), FGF-5 (Zhan *et al., Mol. Cell Biol.* 8: 3487, 1988), FGF-6 (Marics *et al., Oncogene* 4: 335, 1989); keratinocyte growth factor/ FGF-7 (Finch *et al., Science* 245: 752, 1989), FGF-8 (Tanaka *et al., Proc. Natl. Acad. Sci. USA* 89: 8928, 1992), and FGF-9 (Miyamoto *et al., Mol. Cell Biol.* 13: 4251, 1993).

Figure 3 shows a dendrogram in which the length of each path connecting any pair of FGF family members is proportional to the degree of amino acid sequence divergence of that pair.

Figure 4 shows that the gene encoding FHF-1 is located on human chromosome 3. The human specific hybridization is found on chromosome 3.

Figure 5 shows the production of FHF-1 in transfected human embryonic kidney cells. Lanes 1, 3, and 5, total cell protein; lanes 2, 4, and 6 protein present in the medium (secreted protein). Lanes 1 and 2, transfection with cDNA encoding human growth hormone; lanes 3 and 4, transfection with cDNA encoding FHF-1; lanes 5 and 6, transfection with cDNA encoding a novel surface receptor fused to an immunoglobulin constant region. Protein standards are shown to the left; from top to bottom their molecular masses are 220, 97, 66, 46, 30, 21.5, and 14.3 kD.

Figure 6 shows the tissue specificity of FHF-1 expression. Ten micrograms of total RNA from the indicated mouse tissues was prepared (Chomczinski & Sacchi. Anal. Biochem. 162: 156, 1987) and used for RNAse protection (Ausabel et al., Current Protocols in Molecular Biology; New York: Wiley Interscience, 1987) with a mouse FHF-1 antisense probe that spanned 212 bases of exon 1 and the adjacent 100 bases of intron 1. RNAse protection at the size expected for the 212 base exon 1 region of the probe (arrowhead) was observed with RNA from brain, eye, and testis.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a growth factor, FHF-1, and a polynucleotide sequence encoding FHF-1. FHF-1 is expressed at high levels in brain, eye and testes tissues. In one embodiment, the invention provides a method for detection of a cell proliferative disorder of central nervous system or testes origin which is associated with FHF-1 expression or function. In another embodiment, the invention provides a method for treating a cell proliferative or immunologic disorder by using an agent which suppresses or enhances FHF-1 expression or activity.

The structural homology between the FHF-1 protein of this invention and the members of the FGF family, indicates that FHF-1 is a new member of the family of growth factors. Based on the known activities of many of the other members, it can be expected that FHF-1 will also possess biological activities that will make it useful as a diagnostic and therapeutic reagent.

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Many growth factors have expression patterns or possess activities that relate to the function of the nervous system. For example, one growth factor in the TGF family, namely GDNF, has been shown to be a potent neurotrophic factor that can promote the survival of dopaminergic neurons (Lin, *et al., Science*, 260:1130). Another family member, namely dorsalin-1, is capable of promoting the differentiation of neural crest cells (Basler, *et al., Cell*, 73:687, 1993). The inhibins and activins have been shown to be expressed in the brain (Meunier, *et al., Proc. Nat'l. Acad. Sci.*, USA, 85:247, 1988; Sawchenko, *et al., Nature*, 334:615, 1988), and activin has been shown to be capable of functioning as a nerve cell survival molecule (Schubert, *et al., Nature*, 344:868, 1990). Another TGF family member, namely GDF-1, is nervous system-specific in its expression pattern (Lee, *Proc. Nat'l. Acad. Sci., USA*, 88:4250, 1991), and certain other family members, such as Vgr-1 (Lyons, *et al., Proc. Nat'l. Acad. Sci., USA,* 86:4554, 1989; Jones, *et al., Development,* 111:581, 1991), OP-1 (Ozkaynak, *et al., J. Biol. Chem.,* 267:25220, 1992), and BMP-4 (Jones, *et al., Development,* 111:531, 1991), are also known to be expressed in the nervous system.

The expression of FHF-1 in brain and eye suggests that FHF-1 may also possess activities that relate to the function of the nervous system. FHF-1 may have neurotrophic activities for various neuronal populations. Hence, FHF-1 may have *in vitro* and *in vivo* applications in the treatment of neurodegenerative diseases, such as amyotrophic lateral sclerosis, or in maintaining cells or tissues in culture prior to transplantation.

In a first embodiment, the present invention provides a sbstantially pure fibroblast growth factor homologous factor-1 (FHF-1) characterized by aving a molecular weight of about 30kD as determined by reducing SDS-PAGE and having essentially the amino acid sequence of SEQ ID NO:2. The term "substantially pure" as used herein refers to FHF-1 which is substantially free of other proteins, lipids, carbohydrates or other materials with which it is naturally associated. One skilled in the art can purify FHF-1 using standard techniques for protein purification. The substantially pure polypeptide will yield a single major band on a non-reducing polyacrylamide gel. The purity of the FHF-1 polypeptide can also be determined by amino-terminal amino acid sequence analysis. FHF-1 polypeptide includes functional fragments of the polypeptide, as long as the activity of FHF-1 remains.

Smaller peptides containing the biological activity of FHF-1 are included in the invention.

The invention provides polynucleotides encoding the FHF-1 polypeptide. These polynucleotides include DNA, cDNA and RNA sequences which encode FHF-1. It is understood that all polynucleotides encoding all or a portion of FHF-1 are also included herein, as long as they encode a polypeptide with FHF-1 activity. Such polynucleotides include naturally occurring, synthetic, and intentionally manipulated polynucleotides. For example, FHF-1 polynucleotide may be subjected to site-directed mutagenesis. The polynucleotide sequence for FHF-1 also includes antisense sequences. The polynucleotides of the invention include sequences that are degenerate as a result of the genetic code. There are 20 natural amino acids, most of which are specified by more than one codon. Therefore, all degenerate nucleotide sequences are included in the invention as long as the amino acid sequence of FHF-1 polypeptide encoded by the nucleotide sequence is functionally unchanged.

Specifically disclosed herein is a DNA sequence encoding the human FHF-1 gene. The sequence contains an open reading frame encoding a polypeptide 244 amino acids in length. The human FHF-1 inititiator methionine codon shown in FIGURE 1 at position 332-334 is the first ATG codon following the in-frame stop codon at nucleotides 323-325; a good consensus ribosome binding site (TGGCCATGG; Kozak, *Nucleic Acids Res.*, 15: 8125, 1987) is found at this position. The next methionine codon within the open reading frame is encountered 86 codons 3' of the putative initiator methionine codon. As observed for aFGF and bFGF, the amino-terminus of the primary translation product of FHF-1 does not conform to the consensus sequence for a signal peptide to direct cotranslational insertion across the endoplasmic reticulum membrane. The FHF-1 sequence lacks potential asn-X-ser/thr site for asparagine-linked glycosylation. Preferably, the human FHF-1 nucleotide sequence is SEQ ID NO:1 and the deduced amino acid sequence is preferably SEQ ID NO:2.

The polynucleotide encoding FHF-1 includes SEQ ID NO:1 as well as nucleic acid sequences complementary to SEQ ID NO:1. A complementary sequence may include an antisense nucleotide. When the sequence is RNA, the deoxynucleotides

A, G, C, and T of SEQ ID NO:1 is replaced by ribonucleotides A, G, C, and U, respectively. Also included in the invention are fragments of the above-described nucleic acid sequences that are at least 15 bases in length, which is sufficient to permit the fragment to selectively hybridize to DNA that encodes the protein of SEQ ID NO:2 under physiological conditions. Specifically, the fragments should hybridize to DNA encoding FHF-1 protein under stringent conditions.

The FGF family member most homologous to FHF-1 is FGF-9, which shares 27% amino acid identity when aligned with 10 gaps. Minor modifications of the FHF-1 primary amino acid sequence may result in proteins which have substantially equivalent activity as compared to the FHF-1 polypeptide described herein. Such proteins include those as defined by the term "having essentially the amino acid sequence of SEQ ID NO:2". Such modifications may be deliberate, as by site-directed mutagenesis, or may be spontaneous. All of the polypeptides produced by these modifications are included herein as long as the biological activity of FHF-1 still exists. Further, deletion of one or more amino acids can also result in a modification of the structure of the resultant molecule without significantly altering its biological activity. This can lead to the development of a smaller active molecule which would have broader utility. For example, one can remove amino or carboxy terminal amino acids which are not required for FHF-1 biological activity.

The FHF-1 polypeptide of the invention encoded by the polynucleotide of the invention includes the disclosed sequence (SEQ ID NO:2) and conservative variations thereof. The term "conservative variation" as used herein denotes the replacement of an amino acid residue by another, biologically similar residue. Examples of conservative variations include the substitution of one hydrophobic residue such as isoleucine, valine, leucine or methionine for another, or the substitution of one polar residue for another, such as the substitution of arginine for lysine, glutamic for aspartic acid, or glutamine for asparagine, and the like. The term "conservative variation" also includes the use of a substituted amino acid in place of an unsubstituted parent amino acid provided that antibodies raised to the substituted polypeptide also immunoreact with the unsubstituted polypeptide.

DNA sequences of the invention can be obtained by several methods. For example, the DNA can be isolated using hybridization techniques which are well known in the art. These include, but are not limited to: 1) hybridization of genomic or cDNA libraries with probes to detect homologous nucleotide sequences, 2) polymerase chain reaction (PCR) on genomic DNA or cDNA using primers capable of annealing to the DNA sequence of interest, and 3) antibody screening of expression libraries to detect cloned DNA fragments with shared structural features.

Preferably the FHF-1 polynucleotide of the invention is derived from a mammalian organism, and most preferably from human. Screening procedures which rely on nucleic acid hybridization make it possible to isolate any gene sequence from any organism, provided the appropriate probe is available. Oligonucleotide probes, which correspond to a part of the sequence encoding the protein in question, can be synthesized chemically. This requires that short, oligopeptide stretches of amino acid sequence must be known. The DNA sequence encoding the protein can be deduced from the genetic code, however, the degeneracy of the code must be taken into account. It is possible to perform a mixed addition reaction when the sequence is degenerate. This includes a heterogeneous mixture of denatured double-stranded DNA. For such screening, hybridization is preferably performed on either single-stranded DNA or denatured double-stranded DNA. Hybridization is particularly useful in the detection of cDNA clones derived from sources where an extremely low amount of mRNA sequences relating to the polypeptide of interest are present. In other words, by using stringent hybridization conditions directed to avoid non-specific binding, it is possible, for example, to allow the autoradiographic visualization of a specific cDNA clone by the hybridization of the target DNA to that single probe in the mixture which is its complete complement (Wallace, *et al., Nucl. Acid Res.*, 9:879, 1981; Maniatis, *et al., Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor, N.Y. 1989).

The development of specific DNA sequences encoding FHF-1 can also be obtained by: 1) isolation of double-stranded DNA sequences from the genomic DNA; 2) chemical manufacture of a DNA sequence to provide the necessary codons for the polypeptide of interest; and 3) *in vitro* synthesis of a double-stranded DNA sequence by reverse transcription of mRNA isolated from a eukaryotic donor cell. In the latter

case, a double-stranded DNA complement of mRNA is eventually formed which is generally referred to as cDNA.

Of the three above-noted methods for developing specific DNA sequences for use in recombinant procedures, the isolation of genomic DNA isolates is the least common. This is especially true when it is desirable to obtain the microbial expression of mammalian polypeptides due to the presence of introns.

The synthesis of DNA sequences is frequently the method of choice when the entire sequence of amino acid residues of the desired polypeptide product is known. When the entire sequence of amino acid residues of the desired polypeptide is not known, the direct synthesis of DNA sequences is not possible and the method of choice is the synthesis of cDNA sequences. Among the standard procedures for isolating cDNA sequences of interest is the formation of plasmid- or phage-carrying cDNA libraries which are derived from reverse transcription of mRNA which is abundant in donor cells that have a high level of genetic expression. When used in combination with polymerase chain reaction technology, even rare expression products can be cloned. In those cases where significant portions of the amino acid sequence of the polypeptide are known, the production of labeled single or double-stranded DNA or RNA probe sequences duplicating a sequence putatively present in the target cDNA may be employed in DNA/DNA hybridization procedures which are carried out on cloned copies of the cDNA which have been denatured into a single-stranded form (Jay, *et al., Nucl. Acid Res.*, 11:2325, 1983).

A cDNA expression library, such as lambda gt11, can be screened indirectly for FHF-1 peptides having at least one epitope, using antibodies specific for FHF-1. Such antibodies can be either polyclonally or monoclonally derived and used to detect expression product indicative of the presence of FHF-1 cDNA.

DNA sequences encoding FHF-1 can be expressed *in vitro* by DNA transfer into a suitable host cell. "Host cells" are cells in which a vector can be propagated and its DNA expressed. The term also includes any progeny of the subject host cell. It is understood that all progeny may not be identical to the parental cell since there may be mutations that occur during replication. However, such progeny are included

when the term "host cell" is used. Methods of stable transfer, meaning that the foreign DNA is continuously maintained in the host, are known in the art.

In the present invention, the FHF-1 polynucleotide sequences may be inserted into a recombinant expression vector. The term "recombinant expression vector" refers to a plasmid, virus or other vehicle known in the art that has been manipulated by insertion or incorporation of the FHF-1 genetic sequences. Such expression vectors contain a promoter sequence which facilitates the efficient transcription of the inserted genetic sequence of the host. The expression vector typically contains an origin of replication, a promoter, as well as specific genes which allow phenotypic selection of the transformed cells. Vectors suitable for use in the present invention include, but are not limited to the T7-based expression vector for expression in bacteria (Rosenberg, *et al.*, *Gene*, 56:125, 1987), the pMSXND expression vector for expression in mammalian cells (Lee and Nathans, *J. Biol. Chem.*, 263:3521, 1988) and baculovirus-derived vectors for expression in insect cells. The DNA segment can be present in the vector operably linked to regulatory elements, for example, a promoter (e.g., T7, metallothionein I, or polyhedrin promoters).

Polynucleotide sequences encoding FHF-1 can be expressed in either prokaryotes or eukaryotes. Hosts can include microbial, yeast, insect and mammalian organisms. Methods of expressing DNA sequences having eukaryotic or viral sequences in prokaryotes are well known in the art. Biologically functional viral and plasmid DNA vectors capable of expression and replication in a host are known in the art. Such vectors are used to incorporate DNA sequences of the invention.

Transformation of a host cell with recombinant DNA may be carried out by conventional techniques as are well known to those skilled in the art. Where the host is prokaryotic, such as *E. coli*, competent cells which are capable of DNA uptake can be prepared from cells harvested after exponential growth phase and subsequently treated by the $CaCl_2$ method using procedures well known in the art. Alternatively, $MgCl_2$ or RbCl can be used. Transformation can also be performed after forming a protoplast of the host cell if desired.

When the host is a eukaryote, such methods of transfection of DNA as calcium phosphate co-precipitates, conventional mechanical procedures such as micro-

injection, electroporation, insertion of a plasmid encased in liposomes, or virus vectors may be used. Eukaryotic cells can also be cotransformed with DNA sequences encoding the FHF-1 of the invention, and a second foreign DNA molecule encoding a selectable phenotype, such as the herpes simplex thymidine kinase gene. Another method is to use a eukaryotic viral vector, such as simian virus 40 (SV40) or bovine papilloma virus, to transiently infect or transform eukaryotic cells and express the protein. (see for example, *Eukaryotic Viral Vectors*, Cold Spring Harbor Laboratory, Gluzman ed., 1982).

Isolation and purification of microbial expressed polypeptide, or fragments thereof, provided by the invention, may be carried out by conventional means including preparative chromatography and immunological separations involving monoclonal or polyclonal antibodies.

The FHF-1 polypeptides of the invention can also be used to produce antibodies which are immunoreactive or bind to epitopes of the FHF-1 polypeptides. Antibody which consists essentially of pooled monoclonal antibodies with different epitopic specificities, as well as distinct monoclonal antibody preparations are provided. Monoclonal antibodies are made from antigen containing fragments of the protein by methods well known in the art (Kohler, *et al., Nature*, 256:495, 1975; *Current Protocols in Molecular Biology*, Ausubel, *et al.*, ed., 1989).

The term "antibody" as used in this invention includes intact molecules as well as fragments thereof, such as Fab, $F(ab')_2$, and Fv which are capable of binding the epitopic determinant. These antibody fragments retain some ability to selectively bind with its antigen or receptor and are defined as follows:

(1) Fab, the fragment which contains a monovalent antigen-binding fragment of an antibody molecule can be produced by digestion of whole antibody with the enzyme papain to yield an intact light chain and a portion of one heavy chain;

(2) Fab', the fragment of an antibody molecule can be obtained by treating whole antibody with pepsin, followed by reduction, to yield an intact light chain and a portion of the heavy chain; two Fab' fragments are obtained per antibody molecule;

(3) $(Fab')_2$, the fragment of the antibody that can be obtained by treating whole antibody with the enzyme pepsin without subsequent reduction; $F(ab')_2$ is a dimer of two Fab' fragments held together by two disulfide bonds;

(4) Fv, defined as a genetically engineered fragment containing the variable region of the light chain and the variable region of the heavy chain expressed as two chains; and

(5) Single chain antibody ("SCA"), defined as a genetically engineered molecule containing the variable region of the light chain, the variable region of the heavy chain, linked by a suitable polypeptide linker as a genetically fused single chain molecule.

Methods of making these fragments are known in the art. (See for example, Harlow and Lane, *Antibodies: A Laboratory Manual*, Cold Spring Harbor Laboratory, New York (1988), incorporated herein by reference).

As used in this invention, the term "epitope" means any antigenic determinant on an antigen to which the paratope of an antibody binds. Epitopic determinants usually consist of chemically active surface groupings of molecules such as amino acids or sugar side chains and usually have specific three dimensional structural characteristics, as well as specific charge characteristics.

Antibodies which bind to the FHF-1 polypeptide of the invention can be prepared using an intact polypeptide or fragments containing small peptides of interest as the immunizing antigen. The polypeptide or a peptide used to immunize an animal can be derived from translated cDNA (see for example, EXAMPLES 4 and 6) or chemical synthesis which can be conjugated to a carrier protein, if desired. Such commonly used carriers which are chemically coupled to the peptide include keyhole limpet hemocyanin (KLH), thyroglobulin, bovine serum albumin (BSA), and tetanus toxoid. The coupled peptide is then used to immunize the animal (*e.g.*, a mouse, a rat, or a rabbit).

If desired, polyclonal or monoclonal antibodies can be further purified, for example, by binding to and elution from a matrix to which the polypeptide or a peptide to which

the antibodies were raised is bound. Those of skill in the art will know of various techniques common in the immunology arts for purification and/or concentration of polyclonal antibodies, as well as monoclonal antibodies (See for example, Coligan, *et al.*, Unit 9, *Current Protocols in Immunology*, Wiley Interscience, 1994, incorporated by reference).

It is also possible to use the anti-idiotype technology to produce monoclonal antibodies which mimic an epitope. For example, an anti-idiotypic monoclonal antibody made to a first monoclonal antibody will have a binding domain in the hypervariable region which is the "image" of the epitope bound by the first monoclonal antibody.

The term "cell-proliferative disorder" denotes malignant as well as non-malignant cell populations which often appear to differ from the surrounding tissue both morphologically and genotypically. Malignant cells (*i.e.* cancer) develop as a result of a multistep process. The FHF-1 polynucleotide that is an antisense molecule is useful in treating malignancies of the various organ systems, particularly, for example, cells in the central nervous system, including neural tissue, testes, and cells of the eye. Essentially, any disorder which is etiologically linked to altered expression of FHF-1 could be considered susceptible to treatment with a FHF-1 suppressing reagent. One such disorder is a malignant cell proliferative disorder, for example.

For purposes of the invention, an antibody or nucleic acid probe specific for FHF-1 may be used to detect FHF-1 polypeptide (using antibody) or polynucleotide (using nucleic acid probe) in biological fluids or tissues. The invention provides a method for detecting a cell proliferative disorder of neural tissue or testes, for example, which comprises contacting an anti-FHF-1 antibody or nucleic acid probe with a cell suspected of having a FHF-1 associated disorder and detecting binding to the antibody or nucleic acid probe. The antibody reactive with FHF-1 or the nucleic acid probe is preferably labeled with a compound which allows detection of binding to FHF-1. Any specimen containing a detectable amount of antigen or polynucleotide can be used. A preferred sample of this invention is CNS, *e.g.*, neural tissue or cerebrospinal fluid, testes, or eye tissue. The level of FHF-1 in the suspect cell can

be compared with the level in a normal cell to determine whether the subject has a FHF-1-associated cell proliferative disorder. Preferably the subject is human.

When the cell component is nucleic acid, it may be necessary to amplify the nucleic acid prior to binding with an FHF-1 specific probe. Preferably, polymerase chain reaction (PCR) is used, however, other nucleic acid amplification procedures such as ligase chain reaction (LCR), ligated activated transcription (LAT) and nucleic acid sequence-based amplification (NASBA) may be used.

The antibodies of the invention can be used in any subject in which it is desirable to administer *in vitro* or *in vivo* immunodiagnosis or immunotherapy. The antibodies of the invention are suited for use, for example, in immunoassays in which they can be utilized in liquid phase or bound to a solid phase carrier. In addition, the antibodies in these immunoassays can be detectably labeled in various ways. Examples of types of immunoassays which can utilize antibodies of the invention are competitive and non-competitive immunoassays in either a direct or indirect format. Examples of such immunoassays are the radioimmunoassay (RIA) and the sandwich (immunometric) assay. Detection of the antigens using the antibodies of the invention can be done utilizing immunoassays which are run in either the forward, reverse, or simultaneous modes, including immunohistochemical assays on physiological samples. Those of skill in the art will know, or can readily discern, other immunoassay formats without undue experimentation.

The antibodies of the invention can be bound to many different carriers and used to detect the presence of an antigen comprising the polypeptide of the invention. Examples of well-known carriers include glass, polystyrene, polypropylene, polyethylene, dextran, nylon, amylases, natural and modified celluloses, polyacrylamides, agaroses and magnetite. The nature of the carrier can be either soluble or insoluble for purposes of the invention. Those skilled in the art will know of other suitable carriers for binding antibodies, or will be able to ascertain such, using routine experimentation.

There are many different labels and methods of labeling known to those of ordinary skill in the art. Examples of the types of labels which can be used in the present invention include enzymes, radioisotopes, fluorescent compounds, colloidal metals,

chemiluminescent compounds, phosphorescent compounds, and bioluminescent compounds. Those of ordinary skill in the art will know of other suitable labels for binding to the antibody, or will be able to ascertain such, using routine experimentation.

Another technique which may also result in greater sensitivity consists of coupling the antibodies to low molecular weight haptens. These haptens can then be specifically detected by means of a second reaction. For example, it is common to use such haptens as biotin, which reacts with avidin, or dinitrophenyl, puridoxal, and fluorescein, which can react with specific antihapten antibodies.

In using the monoclonal antibodies of the invention for the *in vivo* detection of antigen, the detectably labeled antibody is given a dose which is diagnostically effective. The term "diagnostically effective" means that the amount of detectably labeled monoclonal antibody is administered in sufficient quantity to enable detection of the site having the antigen comprising a polypeptide of the invention for which the monoclonal antibodies are specific.

The concentration of detectably labeled monoclonal antibody which is administered should be sufficient such that the binding to those cells having the polypeptide is detectable compared to the background. Further, it is desirable that the detectably labeled monoclonal antibody be rapidly cleared from the circulatory system in order to give the best target-to-background signal ratio.

As a rule, the dosage of detectably labeled monoclonal antibody for in vivo diagnosis will vary depending on such factors as age, sex, and extent of disease of the individual. Such dosages may vary, for example, depending on whether multiple injections are given, antigenic burden, and other factors known to those of skill in the art.

For *in vivo* diagnostic imaging, the type of detection instrument available is a major factor in selecting a given radioisotope. The radioisotope chosen must have a type of decay which is detectable for a given type of instrument. Still another important factor in selecting a radioisotope for *in vivo* diagnosis is that deleterious radiation with respect to the host is minimized. Ideally, a radioisotope used for *in vivo* imaging will

lack a particle emission, but produce a large number of photons in the 140-250 keV range, which may readily be detected by conventional gamma cameras.

For *in vivo* diagnosis radioisotopes may be bound to immunoglobulin either directly or indirectly by using an intermediate functional group. Intermediate functional groups which often are used to bind radioisotopes which exist as metallic ions to immunoglobulins are the bifunctional chelating agents such as diethylenetriaminepentacetic acid (DTPA) and ethylenediaminetetraacetic acid (EDTA) and similar molecules. Typical examples of metallic ions which can be bound to the monoclonal antibodies of the invention are ^{111}In, ^{97}Ru, ^{67}Ga, ^{68}Ga, ^{72}As, ^{89}Zr, and ^{201}Tl.

The monoclonal antibodies of the invention can also be labeled with a paramagnetic isotope for purposes of *in vivo* diagnosis, as in magnetic resonance imaging (MRI) or electron spin resonance (ESR). In general, any conventional method for visualizing diagnostic imaging can be utilized. Usually gamma and positron emitting radioisotopes are used for camera imaging and paramagnetic isotopes for MRI. Elements which are particularly useful in such techniques include ^{157}Gd, ^{55}Mn, ^{162}Dy, ^{52}Cr, and ^{56}Fe.

The monoclonal antibodies or polynucleotides of the invention can be used *in vitro* and *in vivo* to monitor the course of amelioration of a FHF-1-associated disease in a subject. Thus, for example, by measuring the increase or decrease in the number of cells expressing antigen comprising a polypeptide of the invention or changes in the concentration of such antigen present in various body fluids, it would be possible to determine whether a particular therapeutic regimen aimed at ameliorating the FHF-1-associated disease is effective. The term "ameliorate" denotes a lessening of the detrimental effect of the FHF-1-associated disease in the subject receiving therapy.

The present invention identifies a nucleotide sequence that can be expressed in an altered manner as compared to expression in a normal cell, therefore it is possible to design appropriate therapeutic or diagnostic techniques directed to this sequence. Detection of elevated levels of FHF-1 expression is accomplished by hybridization of nucleic acids isolated from a cell suspected of having an FHF-1 associated proliferative disorder with an FHF-1 polynucleotide of the invention. Analysis, such

as Northern Blot analysis, are utilized to quantitate expression of FHF-1. Other standard nucleic acid detection techniques will be known to those of skill in the art.

Treatment of an FHF-1 associated cell proliferative disorder include modulation of FHF-1 gene expression and FHF-1 activity. The term "modulate" envisions the suppression of expression of FHF-1 when it is over-expressed, or augmentation of FHF-1 expression when it is under-expressed. Where a cell-proliferative disorder is associated with the expression of FHF-1, nucleic acid sequences that interfere with FHF-1 expression at the translational level can be used. This approach utilizes, for example, antisense nucleic acid, ribozymes, or triplex agents to block transcription or translation of a specific FHF-1 mRNA, either by masking that mRNA with an antisense nucleic acid or triplex agent, or by cleaving it with a ribozyme. Such disorders include neurodegenerative diseases, for example.

Antisense nucleic acids are DNA or RNA molecules that are complementary to at least a portion of a specific mRNA molecule (Weintraub, *Scientific American*, 262:40, 1990). In the cell, the antisense nucleic acids hybridize to the corresponding mRNA, forming a double-stranded molecule. The antisense nucleic acids interfere with the translation of the mRNA, since the cell will not translate a mRNA that is double-stranded. Antisense oligomers of about 15 nucleotides are preferred, since they are easily synthesized and are less likely to cause problems than larger molecules when introduced into the target FHF-1-producing cell. The use of antisense methods to inhibit the *in vitro* translation of genes is well known in the art (Marcus-Sakura, *Anal.Biochem.*, 172:289, 1988).

Use of an oligonucleotide to stall transcription is known as the triplex strategy since the oligomer winds around double-helical DNA, forming a three-strand helix. Therefore, these triplex compounds can be designed to recognize a unique site on a chosen gene (Maher, *et al., Antisense Res. and Dev.*, 1(3):227, 1991; Helene, C., *Anticancer Drug Design*, 6(6):569, 1991).

Ribozymes are RNA molecules possessing the ability to specifically cleave other single-stranded RNA in a manner analogous to DNA restriction endonucleases. Through the modification of nucleotide sequences which encode these RNAs, it is possible to engineer molecules that recognize specific nucleotide sequences in an

RNA molecule and cleave it (Cech, *J.Amer.Med. Assn.*, 260:3030, 1988). A major advantage of this approach is that, because they are sequence-specific, only mRNAs with particular sequences are inactivated.

There are two basic types of ribozymes namely, *tetrahymena*-type (Hasselhoff, *Nature*, 334:585, 1988) and "hammerhead"-type. *Tetrahymena*-type ribozymes recognize sequences which are four bases in length, while "hammerhead"-type ribozymes recognize base sequences 11-18 bases in length. The longer the recognition sequence, the greater the likelihood that the sequence will occur exclusively in the target mRNA species. Consequently, hammerhead-type ribozymes are preferable to *tetrahymena*-type ribozymes for inactivating a specific mRNA species and 18-based recognition sequences are preferable to shorter recognition sequences.

The present invention also provides gene therapy for the treatment of cell proliferative or immunologic disorders which are mediated by FHF-1 protein. Such therapy would achieve its therapeutic effect by introduction of the FHF-1 antisense polynucleotide into cells having the proliferative disorder. Delivery of antisense FHF-1 polynucleotide can be achieved using a recombinant expression vector such as a chimeric virus or a colloidal dispersion system. Especially preferred for therapeutic delivery of antisense sequences is the use of targeted liposomes.

Various viral vectors which can be utilized for gene therapy as taught herein include adenovirus, herpes virus, vaccinia, or, preferably, an RNA virus such as a retrovirus. Preferably, the retroviral vector is a derivative of a murine or avian retrovirus. Examples of retroviral vectors in which a single foreign gene can be inserted include, but are not limited to: Moloney murine leukemia virus (MoMuLV), Harvey murine sarcoma virus (HaMuSV), murine mammary tumor virus (MuMTV), and Rous Sarcoma Virus (RSV). Preferably, when the subject is a human, a vector such as the gibbon ape leukemia virus (GaLV) is utilized. A number of additional retroviral vectors can incorporate multiple genes. All of these vectors can transfer or incorporate a gene for a selectable marker so that transduced cells can be identified and generated. By inserting a FHF-1 sequence of interest into the viral vector, along with another gene which encodes the ligand for a receptor on a specific target cell, for example, the vector is now target specific. Retroviral vectors can be made target

specific by attaching, for example, a sugar, a glycolipid, or a protein. Preferred targeting is accomplished by using an antibody to target the retroviral vector. Those of skill in the art will know of, or can readily ascertain without undue experimentation, specific polynucleotide sequences which can be inserted into the retroviral genome or attached to a viral envelope to allow target specific delivery of the retroviral vector containing the FHF-1 antisense polynucleotide.

Since recombinant retroviruses are defective, they require assistance in order to produce infectious vector particles. This assistance can be provided, for example, by using helper cell lines that contain plasmids encoding all of the structural genes of the retrovirus under the control of regulatory sequences within the LTR. These plasmids are missing a nucleotide sequence which enables the packaging mechanism to recognize an RNA transcript for encapsidation. Helper cell lines which have deletions of the packaging signal include, but are not limited to Ψ2, PA317 and PA12, for example. These cell lines produce empty virions, since no genome is packaged. If a retroviral vector is introduced into such cells in which the packaging signal is intact, but the structural genes are replaced by other genes of interest, the vector can be packaged and vector virion produced.

Alternatively, NIH 3T3 or other tissue culture cells can be directly transfected with plasmids encoding the retroviral structural genes *gag, pol* and *env*, by conventional calcium phosphate transfection. These cells are then transfected with the vector plasmid containing the genes of interest. The resulting cells release the retroviral vector into the culture medium.

Another targeted delivery system for FHF-1 antisense polynucleotides is a colloidal dispersion system. Colloidal dispersion systems include macromolecule complexes, nanocapsules, microspheres, beads, and lipid-based systems including oil-in-water emulsions, micelles, mixed micelles, and liposomes. The preferred colloidal system of this invention is a liposome. Liposomes are artificial membrane vesicles which are useful as delivery vehicles *in vitro* and *in vivo*. It has been shown that large uni-lamellar vesicles (LUV), which range in size from 0.2-4.0 μm can encapsulate a substantial percentage of an aqueous buffer containing large macromolecules. RNA, DNA and intact virions can be encapsulated within the aqueous interior and be delivered to cells in a biologically active form (Fraley, *et al., Trends Biochem. Sci.*,

6:77, 1981). In addition to mammalian cells, liposomes have been used for delivery of polynucleotides in plant, yeast and bacterial cells. In order for a liposome to be an efficient gene transfer vehicle, the following characteristics should be present: (1) encapsulation of the genes of interest at high efficiency while not compromising their biological activity; (2) preferential and substantial binding to a target cell in comparison to non-target cells; (3) delivery of the aqueous contents of the vesicle to the target cell cytoplasm at high efficiency; and (4) accurate and effective expression of genetic information (Mannino, *et al., Biotechniques*, 6:682, 1988).

The composition of the liposome is usually a combination of phospholipids, particularly high-phase-transition-temperature phospholipids, usually in combination with steroids, especially cholesterol. Other phospholipids or other lipids may also be used. The physical characteristics of liposomes depend on pH, ionic strength, and the presence of divalent cations.

Examples of lipids useful in liposome production include phosphatidyl compounds, such as phosphatidylglycerol, phosphatidylcholine, phosphatidylserine, phosphatidylethanolamine, sphingolipids, cerebrosides, and gangliosides. Particularly useful are diacylphosphatidylglycerols, where the lipid moiety contains from 14-18 carbon atoms, particularly from 16-18 carbon atoms, and is saturated. Illustrative phospholipids include egg phosphatidylcholine, dipalmitoylphosphatidylcholine and distearoylphosphatidylcholine.

The targeting of liposomes can be classified based on anatomical and mechanistic factors. Anatomical classification is based on the level of selectivity, for example, organ-specific, cell-specific, and organelle-specific. Mechanistic targeting can be distinguished based upon whether it is passive or active. Passive targeting utilizes the natural tendency of liposomes to distribute to cells of the reticulo-endothelial system (RES) in organs which contain sinusoidal capillaries. Active targeting, on the other hand, involves alteration of the liposome by coupling the liposome to a specific ligand such as a monoclonal antibody, sugar, glycolipid, or protein, or by changing the composition or size of the liposome in order to achieve targeting to organs and cell types other than the naturally occurring sites of localization.

The surface of the targeted delivery system may be modified in a variety of ways. In the case of a liposomal targeted delivery system, lipid groups can be incorporated into the lipid bilayer of the liposome in order to maintain the targeting ligand in stable association with the liposomal bilayer. Various linking groups can be used for joining the lipid chains to the targeting ligand.

Due to the expression of FHF-1 in the testes, eye and brain, or neural tissue, there are a variety of applications using the polypeptide, polynucleotide, and antibodies of the invention, related to these tissues. Such applications include treatment of cell proliferative and immunologic disorders involving these and other tissues. In addition, FHF-1 may be useful in various gene therapy procedures.

Due to the high level of expression of FHF-1 in the testes, there are a variety of applications using the polypeptide, polynucleotide, and antibodies of the invention related to this tissue. Such applications include treatment of cell proliferative disorders associated with FHF-1 expression in the testes. Various testicular developmental or acquired disorders can also be subject to FHF-1 applications. These may include, but are not limited to viral infection (*e.g.*, viral orchitis), autoimmunity, sperm production or dysfunction, trauma, and testicular tumors. The presence of high levels of FHF-1 in the testis suggests that FHF-1 or an analogue of FHF-1 could be used to increase or decrease male fertility.

The identification of a novel member of the FGF family provides a useful tool for diagnosis, prognosis and therapeutic strategies associated with FHF-1 mediated disorders. Measurement of FHF-1 levels using anti-FHF-1 antibodies is a useful diagnostic for following the progression or recovery from diseases of the nervous system, including: cancer, stroke, neurodegenerative diseases such as Parkinson's disease or Alzheimer's disease, retinal diseases such as retinitis pigmentosa, or viral encephalitis. The presence of high levels of FHF-1 in the central nervous system suggests that the observed low level of FHF-1 in a number of peripheral tissues could reflect FHF-1 in peripheral nerve, and therefore measurement of FHF-1 levels using anti-FHF-1 antibodies could be diagnostic for peripheral neuropathy. The presence of high levels of FHF-1 in the testis suggests that measurement of FHF-1 levels using anti-FHF-1 antibodies could be diagnostic for testicular cancer.

Like other members of the FGF family, FHF-1 likely has mitogenic and/or cell survival activity, therefore FHF-1 or an analogue that mimics FHF-1 action could be used to promote tissue repair or replacement. The presence of FHF-1 in the CNS suggests such a therapeutic role in diseases of the nervous system, including: stroke, neurodegenerative diseases such as Parkinson's disease or Alzheimer's disease, or in retinal degenerative diseases such as retinitis pigmentosa or macular degeneration, or in peripheral neuropathies. Conversely, blocking FHF-1 action either with anti-FHF-1 antibodies or with an FHF-1 antagonist might slow or ameliorate diseases in which excess cell growth is pathological, most obviously cancer.

The following examples are intended to illustrate but not limit the invention. While they are typical of those that might be used, other procedures known to those skilled in the art may alternatively be used.

EXAMPLE 1

IDENTIFICATION OF FHF-1, A NOVEL MEMBER OF THE FGF FAMILY

To identify novel gene products expressed in the human retina, random segments of human retina cDNA clones were partially sequenced, and the resulting partial sequences compared to the sequences available in the public databases.

In detail, an adult human retina cDNA library constructed in lambda gt10 (Nathans, *et al., Science* 232: 193, 1986) was amplified, and the cDNA inserts were excised en mass by cleavage with EcoR I and purified free of the vector by agarose gel electrophoresis. Following heat denaturation of the purified cDNA inserts, a synthetic oligonucleotide containing an EcoR I site at its 5' end and six random nucleotides at its 3' end (5' GACGAGATATTAGAATTCTACTCGNNNNNN) (SEQ ID NO:3) was used to prime two sequential rounds of DNA synthesis in the presence of the Klenow fragment of E. coli DNA polymerase. The resulting duplex molecules were amplified using the polymerase chain reaction (PCR) with a primer corresponding to the unique 5' flanking sequence (5' CCCCCCCCCGACGAGATATTAGAATTCTACTCG) (SEQ ID NO:4). These PCR products, representing a random sampling of the original cDNA inserts, were cleaved with EcoR I, size fractionated by preparative agarose gel electrophoresis to include only segments of approximately 500 bp in length, and

cloned into lambda gt10. Three thousand single plaques from this derivative library were arrayed in 96-well trays and from these clones the inserts were amplified by PCR using flanking vector primers and then sequenced using the dideoxy method and automated fluorescent detection (Applied Biosystems). A single sequencing run from one end of each insert was conceptually translated on both strands in all three reading frames and the six resulting amino acid sequences were used to search for homology in the GenBank nonredundant protein database using the BLASTX searching algorithm.

One partial cDNA sequence was found that showed statistically significant homology to previously described members of the FGF family. Using this partial cDNA as a probe, multiple independent cDNA clones were isolated from the human retina cDNA library, including two that encompass the entire open reading frame and from which complete nucleotide sequences were determined.

EXAMPLE 2

DEDUCED PRIMARY STRUCTURE OF FHF-1

Figure 1 shows the sequence of human FHF-1 deduced from the nucleotide sequences of two independent human retina cDNA clones. The primary translation product of human FHF-1 is predicted to be 244 amino acids in length. The human FHF-1 inititiator methionine codon shown in Figure 1 at position 332-334 is the first ATG codon following the in-frame stop codon at nucleotides 323-325; a good consensus ribosome binding site (CAGCTATGG (SEQ ID NO:5); Kozak, *Nucleic Acids Res.* 15: 8125, 1987) is found at this position. The next methionine codon within the open reading frame is encountered 86 codons 3' of the putative initiator methionine codon. As observed for aFGF and bFGF, the amino-terminus of the primary translation product of FHF-1 does not conform to the consensus sequence for a signal peptide to direct cotranslational insertion across the endoplasmic reticulum membrane. The FHF-1 sequence lacks asn-X-ser/thr sites for asparagine-linked glycosylation.

Alignment of FHF-1 with the other known members of the FGF family is shown in Figure 2 and a dendrogram showing the degree of amino acid similarity is shown in Figure 3. The most homologous FGF family member is FGF-9 which shows

27% amino acid identity with FHF-1 when aligned with 10 gaps. Note that in the central region of each polypeptide, all FGF family members, including FHF-1, share 11 invariant amino acids.

EXAMPLE 3

CHROMOSOMAL LOCALIZATION OF FHF-1

The chromosomal location of FHF-1 was determined by probing a Southern blot containing restriction enzyme digested DNA derived from a panel of 24 human-mouse and human-hamster cell lines, each containing a different human chromosome (Oncor, Gaithersburg, MD). As seen in Figure 4, hybridization of the human FHF-1 probe to human, mouse, and hamster genomic DNA produces distinct hybridizing fragment sizes. Among the hybrid panels, the human-specific hybridization pattern is seen only in the lane corresponding to the hybrid cell line carrying human chromosome 3.

EXAMPLE 4

PRODUCTION OF FHF-1 IN TRANSFECTED HUMAN CELLS

To express FHF-1 in human cells, the complete open reading frame was inserted into the eukaryotic expression vector pCIS (Gorman, *et al., DNA Protein Eng. Tech.* 2: 3, 1990). To increase the efficiency of translation, the region immediately 5' of the initiator methionine coding was converted to an optimal ribosome binding site (CCACC**ATG**G) by PCR amplification with a primer that carried the desired sequence. Following transient transfection of human embryonic kidney cells with the expression construct and a plasmid expressing the simian virus 40 (SV40) large T-antigen (pRSV-TAg; Gorman, *et al., supra*), cells were metabolically labeled with ^{35}S methionine for 6 hours in the absence of serum. As shown in Figure 5, cells transfected with FHF-1 synthesize a single abundant polypeptide with an apparent molecular mass of 30 kD that is not produced by cells transfected with either of two unrelated constructs. This polypeptide corresponds closely to the predicted molecular mass of the primary translation product, 27.4 kD. Figure 5 also shows that cells transfected with a human growth hormone (hGH) expression plasmid efficiently secrete hGH,

whereas FHF-1 accumulates within the transfected cells and fails to be secreted in detectable quantities.

EXAMPLE 5

TISSUE DISTRIBUTION OF FHF-1 mRNA

To determine the tissue distribution of FHF-1 mRNA, RNase protection analysis was performed on total RNA from mouse brain, eye, heart, kidney, liver, lung, spleen, and testis, as well as a yeast tRNA negative control. The probe used was derived from a segment of the mouse FHF-1 gene isolated by hybridization with the full-length human FHF-1 cDNA. As seen in Figure 6, the highest levels of FHF-1 expression are in the brain, eye, and testis. Very low levels of FHF-1 expression were detected in kidney, liver, and lung on a five-fold longer exposure of the autoradiogram.

EXAMPLE 6

PRODUCTION OF ANTIBODIES SPECIFIC FOR FHF-1

To generate anti-FHF-1 antibodies, a DNA segment encompassing the carboxy-terminal 190 amino acids of FHF-1 was inserted into the *E. coli* expression vector pGEMEX (Studier, *et al, Meth. Enzymol.* 185: 60, 1990). The recombinant fusion protein between the T7 gene 10 protein and the carboxy-terminal 190 amino acids of FHF-1 was produced in *E. coli*, purified by preparative polyacrylamide gel electrophoresis, and used to immunize rabbits. Anti-FHF-1 antibodies from immune serum were affinity purified using the fusion protein immobilized onto nitrocellulose; those antibodies directed against the pGEMEX T7 gene10 protein fusion partner were removed by absorption to the purified T7 gene 10 protein immobilized onto nitrocellulose. By Western blotting, the affinity purified anti-FHF-1 antibodies were shown to recognize recombinant FHF-1 produced either in *E. coli* or in human embryonic kidney cells. By immunohistochemical staining the antibodies also specifically recognized recombinant FHF-1 produced in human embryonic kidney cells transfected with the FHF-1 expression plasmid described above. Immunostaining of neural tissues shows anti-FHF-1 immunostaining in the ganglion cell layer and inner

nuclear layers of adult mouse and macaque monkey retinas and in a large number of regions within the adult mouse brain.

Although the invention has been described with reference to the presently preferred embodiment, it should be understood that various modifications can be made without departing from the spirit of the invention. Accordingly, the invention is limited only by the following claims.

SEQUENCE LISTING

(1) GENERAL INFORMATION:

(i) APPLICANT: The Johns Hopkins University School of Medicine

(ii) TITLE OF INVENTION: FIBROBLAST GROWTH FACTOR HOMOLOGOUS FACTOR-1 (FHF-1) AND METHODS OF USE

(iii) NUMBER OF SEQUENCES: 5

(iv) CORRESPONDENCE ADDRESS:
(A) ADDRESSEE: Fish & Richardson P.C.
(B) STREET: 4225 Executive Square, Suite 1400
(C) CITY: La Jolla
(D) STATE: CA
(E) COUNTRY: USA
(F) ZIP: 92037

(v) COMPUTER READABLE FORM:
(A) MEDIUM TYPE: Floppy disk
(B) COMPUTER: IBM PC compatible
(C) OPERATING SYSTEM: PC-DOS/MS-DOS
(D) SOFTWARE: PatentIn Release #1.0, Version #1.30

(vi) CURRENT APPLICATION DATA:
(A) APPLICATION NUMBER:
(B) FILING DATE: 10-MAY-1996
(C) CLASSIFICATION:

(viii) ATTORNEY/AGENT INFORMATION:
(A) NAME: Haile, Ph.D.Lisa A.
(B) REGISTRATION NUMBER: 38,347
(C) REFERENCE/DOCKET NUMBER: 07265/047WO1

(ix) TELECOMMUNICATION INFORMATION:
(A) TELEPHONE: 619/678-5070
(B) TELEFAX: 617/678-5099

(2) INFORMATION FOR SEQ ID NO:1:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 1422 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(VII) IMMEDIATE SOURCE:
(B) CLONE: FHF-1

(ix) FEATURE:
(A) NAME/KEY: CDS
(B) LOCATION: 332..1060

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

```
GAATTCCGCA CACTGCGTTC GGGGTACCAA GTGGAAGGGG AAGAACGATG CCCAAAATAA      60

CAAGACGTGC CTGGGACCGC CCCGCCCCGC CCCCCGGCCG CCAGAGGTTG GGGAAGTTTA     120

CATCTGGATT TTCACACATT TTGTCGCCAC TGCCCAGACT TTGACTAACC TTGTGAGCGC     180

CGGGTTTTCG ATACTGCAGC CTCCTCAAAT TTTAGCACTG CCTCCCCGCG ACTGCCCTTT     240

CCCTGGCCGC CCAGGTCCTG CCCTCGCCCC GGCGGAGCGC AAGCCGGAGG GCGCAGTAGA     300

GGCTGGGGCC TGAGGCCCTC GCTGAGCAGC T ATG GCT GCG GCG ATA GCC AGC         352
                                   Met Ala Ala Ala Ile Ala Ser
                                     1               5

TCC TTG ATC CGG CAG AAG CGG CAG GCG AGG GAG TCC AAC AGC GAC CGA       400
Ser Leu Ile Arg Gln Lys Arg Gln Ala Arg Glu Ser Asn Ser Asp Arg
          10                  15                  20

GTG TCG GCC TCC AAG CGC CGC TCC AGC CCC AGC AAA GAC GGG CGC TCC       448
Val Ser Ala Ser Lys Arg Arg Ser Ser Pro Ser Lys Asp Gly Arg Ser
     25                  30                  35

CTG TGC GAG AGG CAC GTC CTC GGG GTG TTC AGC AAA GTG CGC TTC TGC       496
Leu Cys Glu Arg His Val Leu Gly Val Phe Ser Lys Val Arg Phe Cys
 40                  45                  50                  55

AGC GGC CGC AAG AGG CCG GTG AGG CGG AGA CCA GAA CCC CAG CTC AAA       544
Ser Gly Arg Lys Arg Pro Val Arg Arg Arg Pro Glu Pro Gln Leu Lys
                    60                  65                  70

GGG ATT GTG ACA AGG TTA TTC AGC CAG CAG GGA TAC TTC CTG CAG ATG       592
Gly Ile Val Thr Arg Leu Phe Ser Gln Gln Gly Tyr Phe Leu Gln Met
               75                  80                  85

CAC CCA GAT GGT ACC ATT GAT GGG ACC AAG GAC GAA AAC AGC GAC TAC       640
His Pro Asp Gly Thr Ile Asp Gly Thr Lys Asp Glu Asn Ser Asp Tyr
          90                  95                  100

ACT CTC TTC AAT CTA ATT CCC GTG GGC CTG CGT GTA GTG GCC ATC CAA       688
Thr Leu Phe Asn Leu Ile Pro Val Gly Leu Arg Val Val Ala Ile Gln
     105                 110                 115

GGA GTG AAG GCT AGC CTC TAT GTG GCC ATG AAT GGT GAA GGC TAT CTC       736
Gly Val Lys Ala Ser Leu Tyr Val Ala Met Asn Gly Glu Gly Tyr Leu
120                 125                 130                 135

TAC AGT TCA GAT GTT TTC ACT CCA GAA TGC AAA TTC AAG GAA TCT GTG       784
Tyr Ser Ser Asp Val Phe Thr Pro Glu Cys Lys Phe Lys Glu Ser Val
                140                 145                 150

TTT GAA AAC TAC TAT GTG ATC TAT TCT TCC ACA CTG TAC CGC CAG CAA       832
Phe Glu Asn Tyr Tyr Val Ile Tyr Ser Ser Thr Leu Tyr Arg Gln Gln
           155                 160                 165
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GAA TCA GGC CGA GCT TGG TTT CTG GGA CTC AAT AAA GAA GGT CAA ATT      880
Glu Ser Gly Arg Ala Trp Phe Leu Gly Leu Asn Lys Glu Gly Gln Ile
        170                 175                 180

ATG AAG GGG AAC AGA GTG AAG AAA ACC AAG CCC TCA TCA CAT TTT GTA      928
Met Lys Gly Asn Arg Val Lys Lys Thr Lys Pro Ser Ser His Phe Val
    185                 190                 195

CCG AAA CCT ATT GAA GTG TGT ATG TAC AGA GAA CCA TCG CTA CAT GAA      976
Pro Lys Pro Ile Glu Val Cys Met Tyr Arg Glu Pro Ser Leu His Glu
200                 205                 210                 215

ATT GGA GAA AAA CAA GGG CGT TCA AGG AAA AGT TCT GGA ACA CCA ACC     1024
Ile Gly Glu Lys Gln Gly Arg Ser Arg Lys Ser Ser Gly Thr Pro Thr
                220                 225                 230

ATG AAT GGA GGC AAA GTT GTG AAT CAA GAT TCA ACA TAGCTGAGAA          1070
Met Asn Gly Gly Lys Val Val Asn Gln Asp Ser Thr
            235                 240

CTCTCCCCTT CTTCCCTCTC TCATCCCTTC CCCTTCCCTT CCTTCCCATT TACCCATTTC   1130

CTTCCAGTAA ATCCACCCAA GGAGAGGAAA ATAAAATGAC AACGCAAGAC CTAGTGGCTA   1190

AGATTCTGCA CTCAAAATCT TCCTTTGTGT AGGACAAGAA AATTGAACCA AAGCTTGCTT   1250

GTTGCAATGT GGTAGAAAAT TCACGTGCAC AAAGATTAGC ACACTTAAAA GCAAAGGAAA   1310

AAATAAATCA GAACTCCATA AATATTAAAC TAAACTGTAT TGTTATTAGT AGAAGGCTAA   1370

TTGTAATGAA GACATTAATA AAGATGAAAT AAACTTATTA CTTTCGGAAT TC           1422
```

(2) INFORMATION FOR SEQ ID NO:2:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 243 amino acids
(B) TYPE: amino acid
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

```
Met Ala Ala Ala Ile Ala Ser Ser Leu Ile Arg Gln Lys Arg Gln Ala
 1               5                  10                  15

Arg Glu Ser Asn Ser Asp Arg Val Ser Ala Ser Lys Arg Arg Ser Ser
            20                  25                  30

Pro Ser Lys Asp Gly Arg Ser Leu Cys Glu Arg His Val Leu Gly Val
        35                  40                  45

Phe Ser Lys Val Arg Phe Cys Ser Gly Arg Lys Arg Pro Val Arg Arg
    50                  55                  60

Arg Pro Glu Pro Gln Leu Lys Gly Ile Val Thr Arg Leu Phe Ser Gln
65                  70                  75                  80

Gln Gly Tyr Phe Leu Gln Met His Pro Asp Gly Thr Ile Asp Gly Thr
                85                  90                  95
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Lys Asp Glu Asn Ser Asp Tyr Thr Leu Phe Asn Leu Ile Pro Val Gly
100 105 110

Leu Arg Val Val Ala Ile Gln Gly Val Lys Ala Ser Leu Tyr Val Ala
115 120 125

Met Asn Gly Glu Gly Tyr Leu Tyr Ser Ser Asp Val Phe Thr Pro Glu
130 135 140

Cys Lys Phe Lys Glu Ser Val Phe Glu Asn Tyr Tyr Val Ile Tyr Ser
145 150 155 160

Ser Thr Leu Tyr Arg Gln Gln Glu Ser Gly Arg Ala Trp Phe Leu Gly
165 170 175

Leu Asn Lys Glu Gly Gln Ile Met Lys Gly Asn Arg Val Lys Lys Thr
180 185 190

Lys Pro Ser Ser His Phe Val Pro Lys Pro Ile Glu Val Cys Met Tyr
195 200 205

Arg Glu Pro Ser Leu His Glu Ile Gly Glu Lys Gln Gly Arg Ser Arg
210 215 220

Lys Ser Ser Gly Thr Pro Thr Met Asn Gly Gly Lys Val Val Asn Gln
225 230 235 240

Asp Ser Thr

(2) INFORMATION FOR SEQ ID NO:3:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 30 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

GACGAGATAT TAGAATTCTA CTCGNNNNNN

(2) INFORMATION FOR SEQ ID NO:4:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 33 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

CCCCCCCCCG ACGAGATATT AGAATTCTAC TCG 33

(2) INFORMATION FOR SEQ ID NO:5:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 9 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: single
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

CAGCTATGG 9

CLAIMS

1. Substantially pure fibroblast growth factor homologous factor-1 (FHF-1) characterized by:
   a. having a molecular weight of about 30kD as determined by reducing SDS-PAGE; and
   b. having essentially the amino acid sequence of SEQ ID NO:2.

2. An isolated polynucleotide sequence encoding the FHF-1 polypeptide of claim 1.

3. The polynucleotide of claim 2, wherein the FHF-1 nucleotide sequence is selected from the group consisting of:
   a. SEQ ID NO:1, wherein T can also be U;
   b. nucleic acid sequences complementary to SEQ ID NO:1;
   c. fragments of a. or b. that are at least 15 bases in length and that will selectively hybridize to DNA which encodes the FHF-1 protein of SEQ ID NO:2, under stringent conditions.

4. The polynucleotide sequence of claim 2, wherein the polynucleotide is isolated from a mammalian cell.

5. The polynucleotide of claim 4, wherein the mammalian cell is a human cell.

6. An expression vector including the polynucleotide of claim 2.

7. The vector of claim 6, wherein the vector is a plasmid.

8. The vector of claim 6, wherein the vector is a virus.

9. A host cell stably transformed with the vector of claim 6.

10. The host cell of claim 9, wherein the cell is prokaryotic.

11. The host cell of claim 9, wherein the cell is eukaryotic.

12. An antibody that binds to FHF-1 polypeptide or immunoreactive fragments thereof.

13. The antibody of claim 12, wherein the antibody is polyclonal.

14. The antibody of claim 12, wherein the antibody is monoclonal.

15. A method of detecting a cell proliferative disorder comprising contacting a specimen of a subject suspected of having a FHF-1 associated cell proliferative disorder with a reagent that binds to FHF-1 and detecting binding of the reagent to FHF-1.

16. The method of claim 15, wherein the cell is selected from the group consisting of brain, testes or eye cell.

17. The method of claim 15, wherein the reagent is an antibody which binds to FHF-1.

18. The method of claim 15, wherein the reagent is a polynucleotide which encodes FHF-1 polypeptide, or fragments thereof.

19. The method of claim 15, wherein the detecting is *in vivo*.

20. The method of claim 15, wherein the detection is *in vitro*.

21. The method of claim 17 or 18, wherein the reagent is detectably labeled.

22. The method of claim 21, wherein the detectable label is selected from the group consisting of a radioisotope, a fluorescent compound, a bioluminescent compound and a chemiluminescent compound.

23. A method of treating a cell proliferative disorder associated with expression of FHF-1, comprising contacting the cell having or suspected of having the disorder with a reagent which suppresses the FHF-1 activity.

24. The method of claim 23, wherein the reagent is an anti-FHF-1 antibody.

25. The method of claim 23, wherein the reagent is a FHF-1 antisense sequence.

26. The method of claim 23, wherein the cell is a testes, brain or eye cell.

27. The method of claim 23, wherein the reagent which suppresses FHF-1 activity is introduced to the cell using a vector.

28. The method of claim 27, wherein the vector is a colloidal dispersion system.

29. The method of claim 28, wherein the colloidal dispersion system is a liposome.

30. The method of claim 29, wherein the liposome is essentially target specific.

31. The method of claim 30, wherein the liposome is anatomically targeted.

32. The method of claim 30, wherein the liposome is mechanistically targeted.

33. The method of claim 32, wherein the mechanistic targeting is passive.

34. The method of claim 32, wherein the mechanistic targeting is active.

35. The method of claim 34, wherein the liposome is actively targeted by coupling with a moiety selected from the group consisting of a sugar, a glycolipid, and a protein.

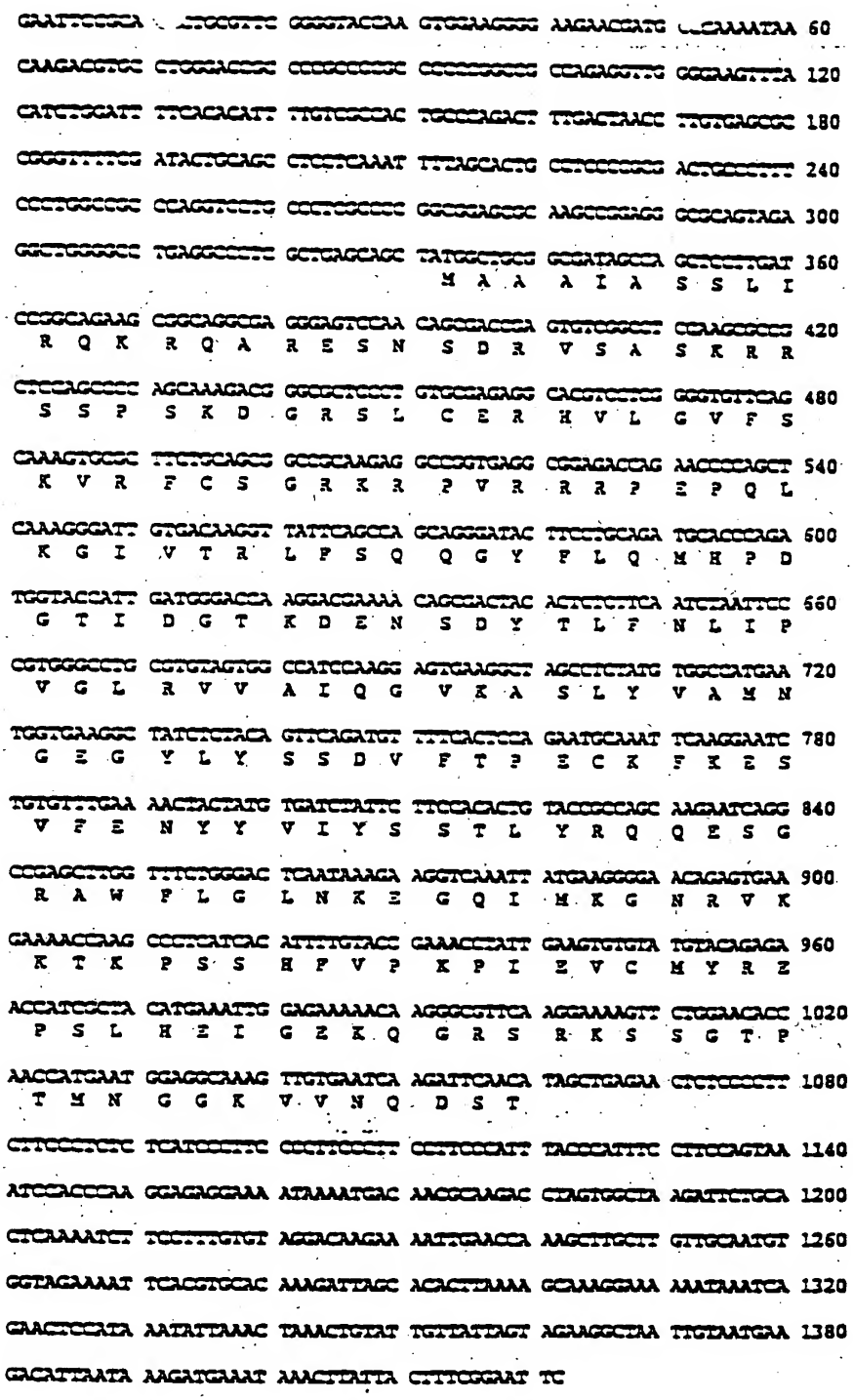
36. The method of claim 35, wherein the protein moiety is an antibody.

37. The method of claim 27, wherein the vector is a virus.

38. The method of claim 37, wherein the virus is an RNA virus.

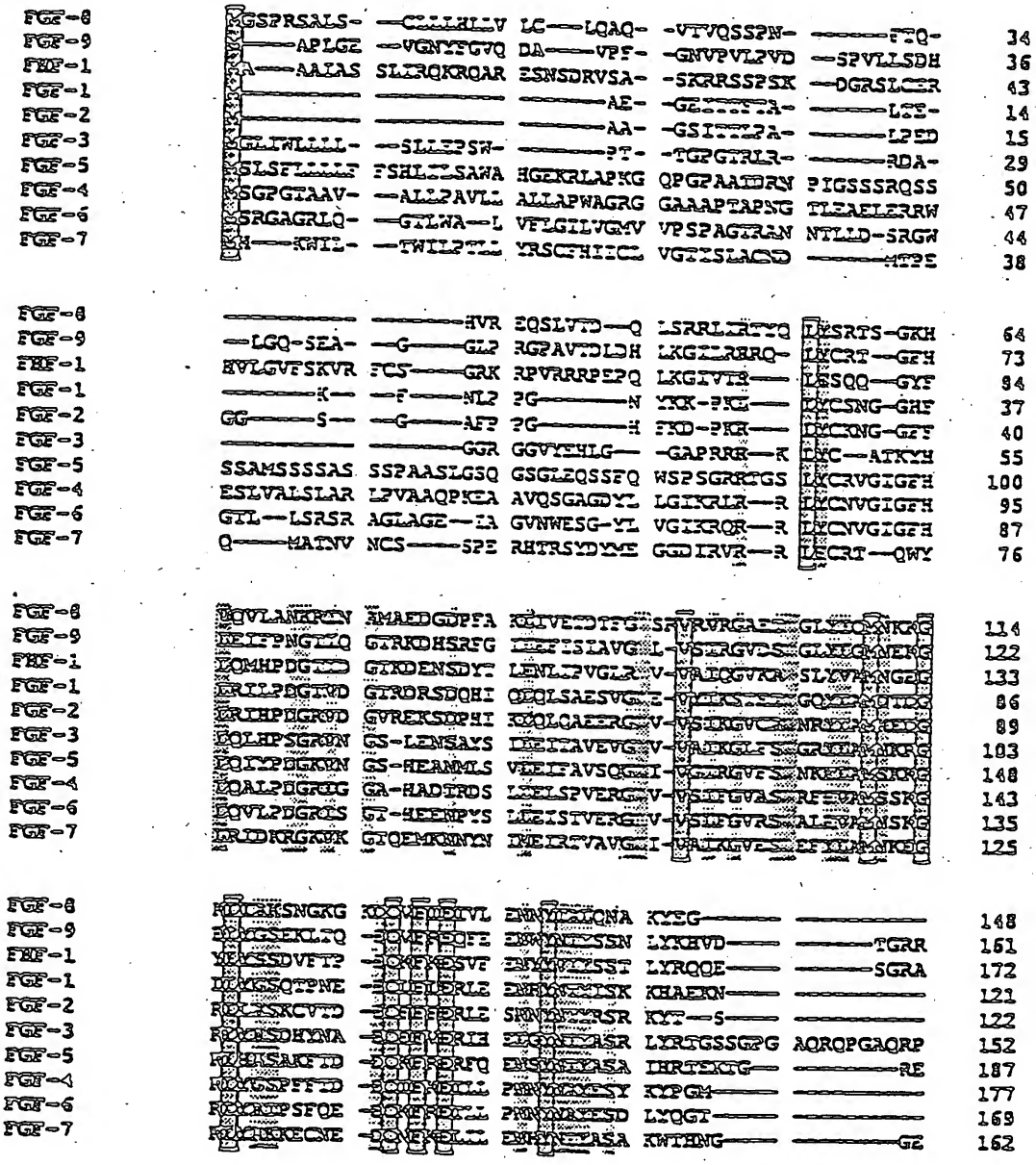
39. The method of claim 38, wherein the RNA virus is a retrovirus.

40. The method of claim 39, wherein the retrovirus is essentially target specific.

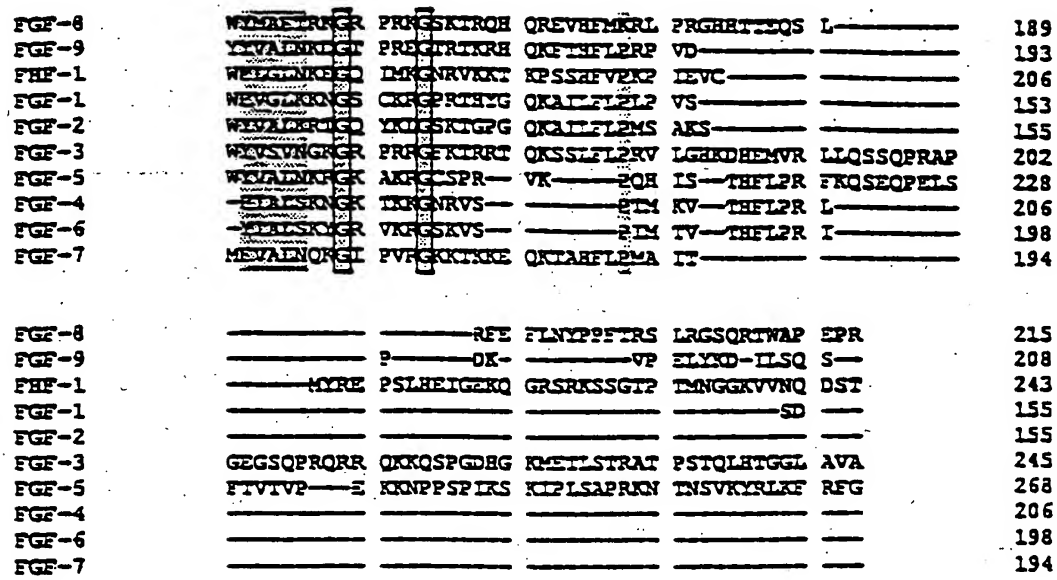


FHF-1 Fig. 1

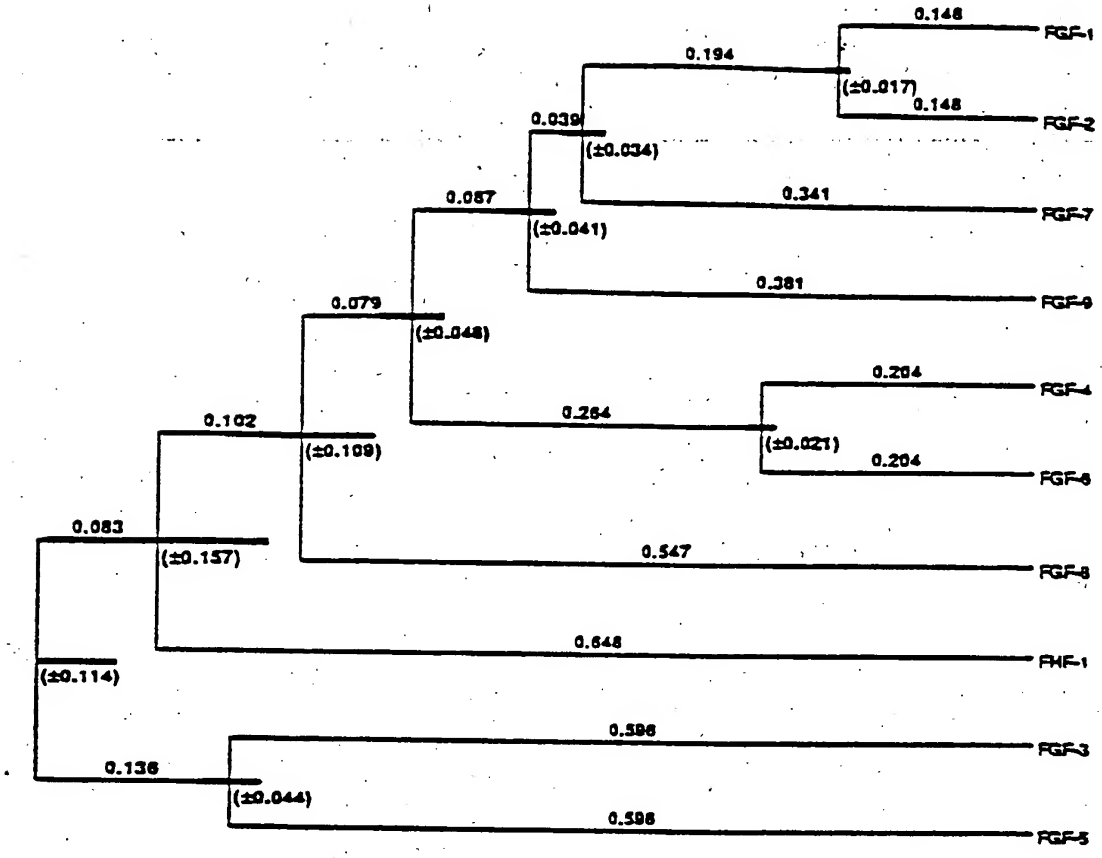
BNSDOCID: <WO___9635708A1_I_>



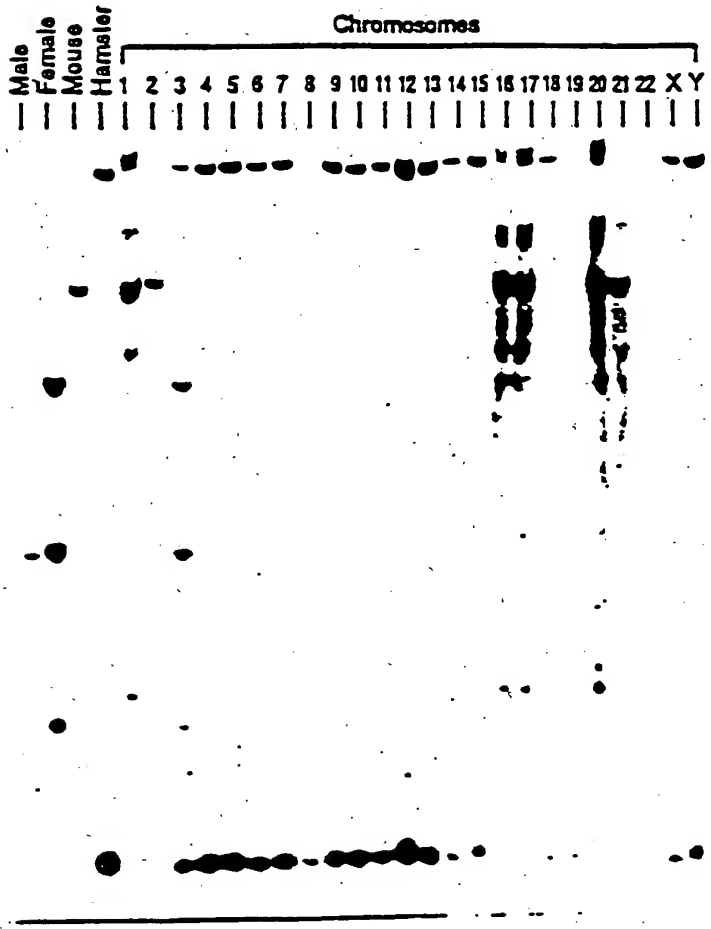
FHF-1 FIG 2.


FGF-8 189
FGF-9 193
FHF-1 206
FGF-1 153
FGF-2 155
FGF-3 202
FGF-5 228
FGF-4 206
FGF-6 198
FGF-7 194
FGF-8 215
FGF-9 208
FHF-1 243
FGF-1 155
FGF-2 155
FGF-3 245
FGF-5 268
FGF-4 206
FGF-6 198
FGF-7 194

FHF-1 FIG 7

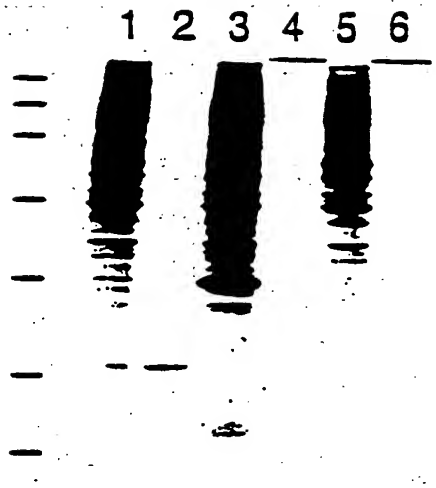

0.148
FGF-1
0.194
(±0.017)
0.148
FGF-2
0.039
(±0.034)
0.341
FGF-7
0.087
(±0.041)
0.381
FGF-9
0.079
(±0.048)
0.204
FGF-4
0.264
0.102
(±0.021)
0.204
FGF-6
(±0.109)
0.083
(±0.157)
0.547
FGF-8
0.648
FHF-1
(±0.114)
0.596
FGF-3
0.136
(±0.044)
0.596
FGF-5

FHF-1 FIG.

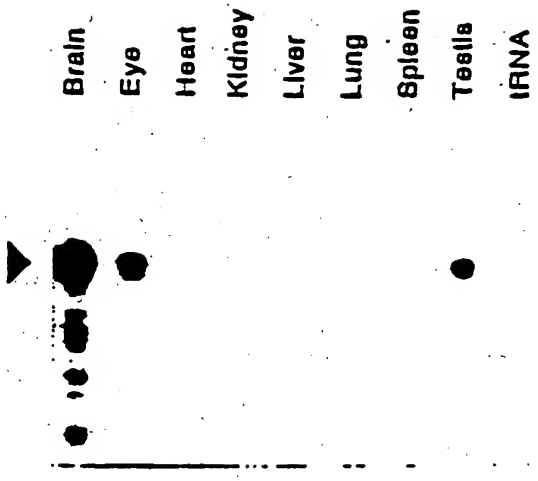


FHF-1 FIG 4

BNSDOCID: <WO___9635708A1_I_>



FHF-1 FIG 5



FHF-1 FIG 6

BNSDOCID: <WO___9635708A1_I_>

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/06664

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :Please See Extra Sheet.
US CL : 530/350; 536/22.1, 23.1; 435/7.1; 514/44
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 530/350; 536/22.1, 23.1; 435/7.1; 514/44

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS, MEDLINE, CAPLUS, WPIDS
search terms: fibroblast growth factor, homologous

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	IIDA et al. Human hst-2 (FGF-6) oncogene: cDNA cloning and characterization. Oncogene. July 1992, Vol.7, pages 303-309, see the entire document.	1-11, 15-16, and 18-22
A	MIYAMOTO et al. Molecular cloning of a novel cytokine cDNA encoding the ninth member of the fibroblast growth factor family, which has a unique secretion property. Molecular and Cellular Biology. July 1993, Vol. 13, No. 7, pages 4251-4259, see the entire document.	1-11, 15-16, and 18-22
A	ZHAN et al. The human FGF-5 Oncogene encodes a novel protein related to fibroblast growth factors. Molecular and Cellular Biology. August 1988, Vol. 8, No. 8, pages 3487-3495, see the entire document .	1-11, 15-16, and 18-22

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 01 JULY 1996	Date of mailing of the international search report 23 JUL 1996
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer ETHAN WRISENANT Telephone No. (703) 308-0196

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/06664

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	MERLO et al. The mouse int-2 gene exhibits basic fibroblast growth factor activity in basci fibroblast growth factor-responsive cell lines. Cell Growth & Differentiation. October 1990. Vol. 1, pages 463-472, see the entire document.	1-11, 15-16, and 18-22
A	BROOKES et al. The mouse homologue of hst/k-FGF:sequence, genome organization and location relative to int-2. Nucleic Acids Research. November 1989. Vol. 17, No. 11, pages 4037-4045, see the entire document.	1-11, 15-16, and 18-22
A	YOSHIDA et al. Genomic sequence of hst, a transforming gene encoding a protein homologous to fibroblast growth factors and the int-2-encoded protein. Proc. Natl. Acad. Sci., USA. October 1987. Vol.84, pages 7305-7309, see the entire documment.	1-11, 15-16, and 18-22
A	PAYSON et al. Cloning of two novel forms of human acidic fibroblast growth factor (aFGF) mRNA. Nucleic Acids Research. March 1993, Vol. 21, No. 3, pages 489-495.	1-11, 15-16, and 18-22

BNSDOCID: <WO___9635708A1_I_>

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/06664

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-11, 15-16, and 18-22

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/06664

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (6):

C07K 1/00,14/00, 17/00; C07H 19/00, 21/00, 21/02, 21/04; A01N 43/04; A61 K 31/70; G01N 33/53

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claim(s) 1-11, 15-16, and 18-22, drawn to fibroblast growth factor homologous factor-1 (FHF-1), a polynucleotide sequence encoding FHF-1, and a method of detecting a cell proliferative disorder.

Group II, claim(s) 12-14,drawn to antibodies against FHF-1.

Group III, claim(s) 15-17 and 19-22, drawn to a method of detecting a cell proliferative disorder using antibodies against FHF-1.

Group IV, claim(s) 23-40, drawn to a method of treating an FHF-1 associated cell proliferative disorder.

The inventions listed as Groups I, II, III, and IV do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: (See MPEP 1875.01) The claims are drawn to two products and three processes of use. In this case Group I contains one product and a process of using said product. Group II contains a second product, while GroupIII contains a process of using this second product. Group IV contains a third process of use. The inventions are linked by a special technical feature (i.e. FHF-1), however, under 37 CFR 1.475(b)and(d) the category first mentioned in the claims, and the first recited invention of each of the other categories related thereto will be considered as the main invention.

BNSDOCID: <WO___9635708A1_I_>